

RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

Vol 65.

December, 1955

No. 6

CONTENTS

THE ROENTGENOLOGIC MANIFESTATIONS OF SYNOVIAL SARCOMA. <i>Richard M. Craig, M.D., David G. Pugh, M.D., and Edward H. Soule, M.D.</i>	837
ANGIOGRAPHY IN THE EVALUATION OF INTRACRANIAL TRAUMA. <i>J. E. Lofstrom, M.D., J. E. Webster, M.D., and E. S. Gurdjian, M.D.</i>	847
PULMONARY ARTERIAL OLIGEMIA IN MITRAL STENOSIS AS REVEALED ON THE PLAIN ROENTGENOGRAM. <i>Felix G. Fleischner, M.D., and Elliot L. Sagall, M.D.</i>	857
BRONCHOGRAPHY IN DIAGNOSIS OF BRONCHOGENIC CARCINOMA IN TWO PATIENTS WITH APPARENTLY NORMAL CHEST FILMS. <i>Judah Zizmor, M.D.</i>	868
PROTECTION MEASURES IN A UNIVERSITY. <i>Titus C. Evans, Ph.D.</i>	875
COBALT 60 PROTECTION DESIGN. <i>C. B. Braestrup and R. T. Mooney</i>	884
RADIATION HAZARD EVALUATION AND CONTROL IN HOSPITALS. <i>G. Ferlazzo, B.S., T. Nicholson, A. Jacobson, B.S., and M. Bushman</i>	892
RADIATION PROTECTION IN THE ATOMIC ENERGY INDUSTRY. A TEN-YEAR REVIEW. <i>H. M. Parker, M.Sc., F.Inst.P.</i>	903
CINEMICROGRAPHIC OBSERVATIONS AND THEORETICAL CONSIDERATIONS ON THE REACTIONS OF LYMPHOCYTES TO X-RAYS. <i>Robert Schrek, M.D.</i>	912
X-RAY ATTENUATION IN LEAD, ALUMINUM, AND CONCRETE IN THE RANGE 275 TO 525 KILOVOLTS. <i>William Miller and R. J. Kennedy</i>	920
INTRAVENOUS CHOLECYSTANGIOGRAPHY. <i>Richard C. Batt, M.D.</i>	926
URETERAL JET PHENOMENON. STREAM OF OPAQUE MEDIUM SIMULATING AN ANOMALOUS CONFIGURATION OF THE URETER. <i>Edmond H. Kalmon, M.D., Donald D. Albers, M.D., and J. Hartwell Dunn, M.D.</i>	933
EDITORIAL: ROENTGEN EXAMINATION OF THE LIVER. <i>Leo G. Rigler, M.D.</i>	936
ANNOUNCEMENTS AND BOOK REVIEWS.	939
ABSTRACTS OF CURRENT LITERATURE.	943
INDEX TO VOLUME 65	969

RADIOLOGY

A MONTHLY PUBLICATION DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

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Vol. 65

DECEMBER 1955

No. 6

The Roentgenologic Manifestations of Synovial Sarcoma¹

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SYNOVIAL SARCOMAS are unique and relatively rare malignant neoplasms frequently arising near, but not necessarily from, the synovium of joint capsules, bursae, or tendon sheaths. This paper presents the clinical and roentgenologic findings in 24 cases of this tumor observed at the Mayo Clinic.

BACKGROUND INFORMATION

The earliest reports of synovial sarcoma are generally accredited to Stüer in 1893 (1), to Salter and Hardie in 1894 (2), and to Lockwood and Turner, both in 1902 (3). Knox (4) credits v. Ruediger Rydygier with presenting the first synovial sarcoma in 1906. Pack and Ariel (5) accept Lejars and Rubens-Duval's report in 1910 as the first adequate presentation of these tumors.

In 1927, Smith (6) suggested the name "synovioma" for such tumors and described their clinical and pathologic aspects. Knox in 1936 and Berger (7) in 1938 reviewed the cases reported in the literature and described new cases of their own. Both writers emphasized the histopathology of synoviomas.

Excellent articles by Bennett in 1947 (8) and by Pack and Ariel in 1950 described these neoplasms in detail. Sum-

maries of the cases reported in the literature were presented by Haagensen and Stout in 1944 (9) and by Tillotson, McDonald, and Janes in 1951 (10). In each paper new cases were added and a complete analysis of all cases previously reported was presented.

Articles dealing with the roentgen manifestations of synovial sarcomas have not been numerous. Lewis in 1940 (11) presented his findings in 4 cases. Others (5, 12-14) have briefly described the roentgenograms in some of their cases. Recently papers by Hale (15) and by Sherman and Chu (16) have more closely analyzed the roentgen features.

Pathology: The normal synovial membrane consists of an intimal lining and a supportive layer of connective tissue. According to Bennett, this lining membrane of specialized mesenchymal cells secretes mucin and regulates the passage of substances between the articular and vascular fluids in the joints. The intimal lining may appear as a single layer of flattened cells or may increase to many layers of round, oval, or cuboidal cells. When this occurs, papillary projections with recesses and crypts may be noted (8). The normal connective-tissue layer frequently is characterized by highly vas-

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cularized zones and may be loose or compact.

Since the term "synovioma" has frequently been used to include both benign and malignant neoplasms arising from synovial membranes, it is probably more correct to use the term "synovial sarcoma" for the tumors considered here. Such neoplasms present both a synovial and a fibrosarcomatous element (10). The relative amount and degree of differentiation of each element may show wide variation. The fibrosarcomatous element produces reticulin, which can be demonstrated with special silver stains.

Synovial sarcomas grow by expansion and are frequently circumscribed. Some are surrounded, completely or in part, by a pseudo-capsule. Others tend to be diffuse and may have a greater tendency to invade bone (13). Some are nodular, and most vary in their greatest diameter from 4 to 10 cm. The growths are of variable consistency and are usually described as pink to gray, with areas of hemorrhage and necrosis commonly present. Gross calcification is occasionally noted.

These neoplasms are not often found in the joint cavity but are usually in close association with joint capsules, bursal walls, and tendon sheaths. Their location varies widely (8, 17). A direct connection between neoplasm and normal synovial tissue cannot usually be demonstrated and, in most instances, the point of origin is obscure.

Clinical Findings: According to Pack and Ariel, synovial sarcomas comprise 8.4 per cent of all malignant neoplasms of the somatic soft tissues. Young adults are most commonly affected. In Tillotson, McDonald, and Janes' series of 222 cases, 70.8 per cent were in patients less than forty years of age. A soft-tissue tumor or swelling in a joint is commonly the first sign. Approximately 40 per cent of the patients have or will have pain as well as a palpable mass or swollen joint (5). Although a mass may have been present for years in some instances, in the majority of cases the tumor has been

detected for less than eighteen months (10). In most studies, males have been found to be affected more frequently than females (9, 10).

The most common sites for synovial sarcoma include the knee, foot, thigh, ankle, hand, and elbow. In Tillotson, McDonald, and Janes' study, lesions in these parts accounted for 80 per cent of the total. According to Pack and Ariel, this is the most common sarcoma involving the hands and feet.

Synovial sarcomas metastasize *via* the blood and lymph channels. Metastatic involvement of the lungs is particularly common and frequently occurs early. Other sites of metastatic lesions include regional lymph nodes, bone, central nervous system, abdominal viscera, and retroperitoneal tissues (10, 18). About a fifth of the patients are living after five years but not all are free of disease (5, 9, 10).

Most of these patients have repeated local excisions and recurrences until amputation is done. Incisional biopsy followed by primary amputation or disarticulation is the treatment of choice. When radical surgical treatment is impossible, some patients will probably benefit from external roentgen therapy (5, 13).

PRESENT STUDY

The records of all cases of synovial sarcoma in the files of the Mayo Clinic were reviewed for the period 1944 to July 1954. Only cases in which roentgenograms had been made were accepted for study. Twenty-four such cases were collected, including 5 (Cases 1, 4, 5, 6, 7) reported previously (10). The clinical findings in the cases studied are summarized in Table I.

The average age of the patients was 31.5 years, approximately two-thirds of them being between fifteen and forty years of age. There were 16 males and 8 females. The most common primary complaint was a palpable mass with or without pain. Only 2 patients did not mention a mass or swelling and 5 patients noted only swelling. About half of the patients

TABLE I: CLINICAL DATA IN 24 CASES OF SYNOVIAL SARCOMA

Case	Age (years) and Sex	Site of Tumor	Duration (months)	Previous Injury	Treatment	
					Elsewhere	Mayo Clinic
1	20 M	Foot	18	—	.....	Excision
2	16 M	Finger	12	+	.....	Amputation
3	53 F	Wrist	16 yr.	—	Excision	Excision, amputation
4	16 F	Hand	11	+	Excision, x-ray	Amputation
5	39 M	Elbow	14	+	Excision, x-ray, amputation	.....
6	26 F	Hip (troch.)	3	+	.....	Excision
7	70 M	Knee	18	+	.....	Amputation
8	32 M	Knee	20 yr.	—	Excision (3)	Amputation, node dissection
9	35 M	Arm	11 yr.	—	Excision	Amputation
10	27 M	Buttock	6½	+	.....	Excision, x-ray
11	18 M	Groin	10	—	Excision (2)	X-ray
12	28 M	Elbow	17 yr.	—	.....	Amputation
13	19 F	Buttock	10	—	.....	.....
14	35 F	Knee	6	—	Excision, x-ray	.....
15	48 M	Knee	2 yr.	+	X-ray	.....
16	46 M	Foot	18	—	.....	Excision, amputation
17	29 M	Elbow	8	—	Excision	X-ray, amputation (2 years later)
18	6 F	Heel	4	—	Incision, x-ray	X-ray, P ³²
19	46 M	Foot	8	—	Excision	Excision, amputation
20	3 F	Elbow	12	—	Excision, radium	Excision, x-ray
21	32 M	Hand	5 yr.	—	Excision	Amputation
22	19 M	Hand	5 yr.	—	Cautery, amputation of finger	Amputation
23	51 M	Thigh	7	—	.....	Biopsy, x-ray
24	41 F	Sacrum	12	+	.....	Excision, radium

complained of pain when first seen at the Clinic.

The tumors had been present eighteen months or less in 17 of the cases, although in 4 a tumor had been noted more than ten years before the patient chose to investigate it. In such instances an increase in size usually brought the patient in for consultation. One tumor was found just anterior to the sacrum, 10 involved the upper extremity, and 13 were in the lower extremity. Tumors in the region of the hip, knee, foot, elbow, and hand were most frequent. Eight patients associated injury with the discovery of the tumor.

Treatment of the patients varied. Ten had received no treatment when first seen at the clinic. Of the remaining 14 patients, 11 had had one or more excisions primarily (Cases 3, 4, 5, 8, 9, 11, 14, 17, 19, 20, 21), 2 (Cases 15 and 18) had received courses of external roentgen therapy, and 1 (Case 22) had undergone amputation of a finger elsewhere. All of these previously treated patients had recurrent neoplasm on clinical examination.

The 10 patients receiving primary treatment at the Clinic were treated as follows: wide excision alone in 2 cases (Cases 1 and 6), amputation alone in 4 (Cases 2, 7, 12, 16), and excision and radiation therapy in 2 (Cases 10 and 24); the 2 remaining patients both consented to biopsy, but 1 (Case 13) refused all further treatment while the other received external roentgen therapy (Case 23).

Treatment of the recurrent tumors was quite similar. Excision was first employed in 2 cases (Cases 3 and 19) and amputation in 5 (Cases 4, 8, 9, 21, 22). Four patients received external roentgen therapy (Cases 11, 17, 18, 20), 1 following excision (Case 20), and an additional 3 patients (Cases 5, 14, 15) were not treated further.

The specimens of tissue from these cases were re-examined and the diagnosis of synovial sarcoma reaffirmed. In 9 of the specimens there was gross or microscopic evidence of calcification (Fig. 1). This number included 3 cases in which the presence of calcification was not apparent in the roentgenogram. In 4 patients



Fig. 1. Cut surface of an infiltrating but moderately well circumscribed synovial sarcoma in the muscles of the forearm. Several areas of hemorrhagic necrosis are demonstrated. The arrow indicates a large deposit of calcium salts which was easily discernible on gross examination.

calcium deposits disclosed by the roentgenogram were not demonstrated in the tissues remaining for study; biopsy alone was done in 1 of these cases, while in the remaining 3 only parts of the neoplasm were available for examination. Altogether, calcification was demonstrated either pathologically or roentgenographically in 13 of the 24 patients.

The gross and histologic characteristics of synovial sarcoma are shown in Figures 1 and 2.

The post-treatment period in many of these cases is too brief to permit evaluation of the prognosis. At present only 3 patients, 1 seen within the past year, are alive and apparently well. Thirteen are known to have died of the neoplasm and 6 are living with known metastatic disease. Two patients are not accounted for.

In this study, an attempt has been made to evaluate the roentgenologic manifestations of synovial sarcoma (Figs. 3 to 7). In the 10 patients without previous treatment, a homogeneous soft-tissue mass was present. In 6 cases the neoplasm was sharply demarcated from the normal soft tissues and lobulation of the tumor was present in 1 of these, while in the other 4 there were masses with only partial encapsulation. In the latter cases a part of the margin of the mass faded impercep-

tibly into the soft tissues. Six of the roentgenograms showed calcification within the neoplasm. The areas of calcification were usually rather large and amorphous. Four of the roentgenograms showed definite destruction of bone by the new growth. This finding suggested actual invasion

TABLE II: ROENTGENOGRAPHIC FINDINGS IN 24 CASES OF SYNOVIAL SARCOMA

Roentgenographic Finding	No. of Cases
Tumor of increased density	18
Discrete margin	10
Lobulation of the mass	3
Amorphous calcification	9
Associated bone destruction	5
Bone destruction (alone)	2
Calcification (alone)	1
None	3
TOTAL	24

rather than erosion of the bone. The tumors in this group varied from 4 to 20 cm. in the greatest diameter.

The roentgenographic appearance was normal in 3 patients with recurrent lesions. Two of these had the diffuse type of neoplasm involving the synovial tissues about the knee, while in the other the pre-operative roentgen appearance was normal in spite of the pathologic finding of a nodular recurrent lesion 2 cm. in diameter. In the 11 remaining patients previously treated before coming to the Clinic, the routine roentgenograms presented positive findings. Evidence of a typical homogeneous soft-tissue mass of increased density, similar to that seen in the untreated cases, was noted in 8. The borders of the neoplasms were sharply delineated in 4 cases and there was lobulation in 2 instances. The margins of the tumors were irregular or incomplete in 4 of the roentgenograms. Calcification was present in 4 instances and invasion of bone was noted in a similar number. Most of these lesions were less than 10 cm. in their greatest diameter. Of the 3 cases in which a definite soft-tissue mass was lacking, dense calcification was present in 1 and bone destruction in 2.

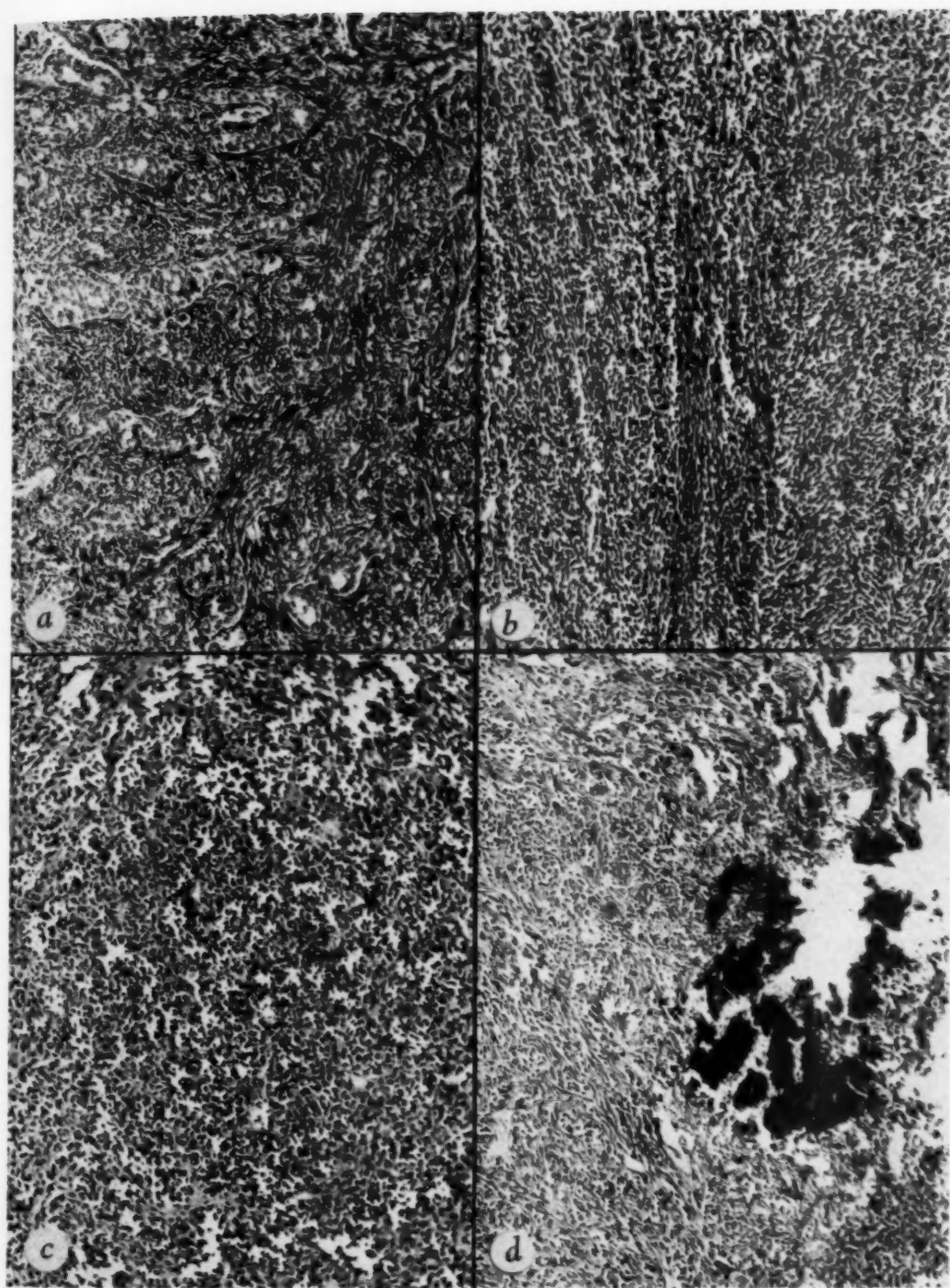


Fig. 2. Sections stained with hematoxylin and eosin ($\times 100$). (a) Classic example of mixture of spindle and cuboidal basic cellular elements. The pseudoglandular spaces often result in erroneous diagnosis of adenocarcinoma. (b) Small spindle-cell elements, often capable of producing collagen, are confused with fibrosarcoma. The small spindle cells and lack of marked pleomorphism help in differentiating the two neoplasms. (c) The small cuboidal and spindle cells may line cleft-like spaces, thus resembling the synovial cells of joints, bursae, and tendon sheaths. (d) Masses of amorphous calcium salts may sometimes be demonstrated microscopically when x-ray and gross examination do not reveal the presence of calcium. Necrosis may or may not be associated with the deposits.



Fig. 3. Case 5. Synovial sarcoma with bone destruction in the medial epicondyle of the left humerus.



Fig. 4. Case 7. Preoperative roentgenogram (a) and roentgenogram of the operative specimen (b) showing enlarged, lobulated mass with bone invasion.



Fig. 5. Case 12. Mass with calcification in the left antecubital space. There is evidence of old fracture of the humerus.

A comparison of the roentgenologic findings in these 2 groups of patients, namely those with primary and those with recurrent synovial sarcomas, reveals little difference in the manifestations of the tumor.

The roentgenographic findings are summarized in Table II.

COMMENT

The clinical findings in this series of patients correspond rather closely with those in previous studies (5, 10, 13). Symptoms are difficult to evaluate and do not often aid in the diagnosis. Trauma is probably of no significance as an etiologic factor, although it is rather common for patients to become aware of the tumor for the first time after some incidental injury. Such neoplasms may have been present for a long time in occasional cases, but more commonly they have been recognized for two years or less prior to consultation. This finding differs somewhat from the observations of others but is supported by Tillotson, McDonald, and



Fig. 6. Case 13. Discrete mass in the left buttock.

Janes in their review of 222 cases of synovial sarcoma.

Until recently, few articles have em-



Fig. 7. Case 23. Smooth-bordered mass in the medial part of the right thigh showing typical amorphous calcification.

phased the roentgenologic manifestations of these neoplasms. The presence of a rounded or lobulated soft-tissue mass near a joint, which may or may not contain calcium, has been described in synovial sarcoma by various authors (12, 13, 15, 16, 19). Lewis, in 1940 (11), presented 4 such cases, in all of which the tumor contained calcium. DeSanto and his associates (13) studied preoperative roentgenograms in 12 of their cases and described a mass in 10 and the presence of calcium in 4 of the neoplasms. Hale (15) reported similar findings in 10 cases and noted calcification in 4 of them and periosteal proliferation in 2. In 1 of the latter 2 cases there was also evidence of bone destruction.

Sherman and Chu (16) re-emphasized the close association of these tumors with a joint, along with their uniform texture as

seen in the roentgenogram. They found synovial reaction, joint effusions, and calcification in the untreated lesions; bone destruction was infrequent in their cases.

The roentgenographic appearance was normal in 3 of the 24 cases in our study. In all 3 the lesions—2 in the knee and 1 in the hand—were recurrent. Two of the lesions were found on pathologic examination, while 1 was discovered on clinical observation.

Of the remaining 21 patients, 18 had a soft-tissue mass of homogeneous density, usually located near the joint of a limb. Ten of these tumors presented sharp, discrete borders, and 3 of these were somewhat lobulated. The remaining 8 showed irregularity and were not as clearly separate from the normal soft tissues. Ten tumors contained calcium, and in all but 1 instance the deposits were relatively large and irregular. Eight of the lesions produced destruction of contiguous bone. The tumors varied from 2 to 20 cm. in their greatest diameter. There was no evidence of joint effusion or periosteal proliferation in any of these cases. The incidence of calcification within the tumor and of bone invasion supports the findings of others but differs from those of Sherman and Chu, who noted calcification in only 3 and bone invasion in 4 of 32 cases studied. These authors also noted no significant differences in the roentgenographic manifestations of primary and recurrent synovial sarcomas.

It appears that untreated tumors are more likely to produce a discrete soft-tissue density than are recurrent lesions. The incidence of calcification and bone invasion was no greater in recurrent than in untreated synovial sarcoma in this study. Recurrent lesions may tend to be slightly smaller than the primary lesion, but this is of little diagnostic value. For practical purposes the roentgenographic findings in primary and recurrent synovial sarcomas are similar.

Roentgenograms in 30 cases of pathologically proved malignant soft-tissue tumor were reviewed for comparison with

the findings in synovial sarcoma. Some significant differences were found. The average age in this group was forty-seven years. A soft-tissue mass was present in two-thirds of the cases and in almost all instances tumor margins were not sharply separated from the soft tissues. In most cases the density of the mass was not as homogeneous as in synovial sarcoma. Calcification within the tumor and bone destruction were infrequent. In Sullivan's (20) review of 107 fibrosarcomas involving the soft tissues of the extremities, he found only 5 cases in which multiple small calcific areas were present. Twenty of the tumors in our 30 cases were found between the buttock and the knee. Almost all these differences would be of value in distinguishing fibrosarcomas from synovial sarcomas. Liposarcomas are usually massive tumors and characteristically contain droplets of radiolucent fat, which give them an irregular density.

In many cases the diagnosis of synovial sarcoma can be suggested by study of the preoperative roentgenogram.

CONCLUSIONS

1. Synovial sarcomas are relatively rare malignant neoplasms, usually associated with synovium-lined structures.
2. These tumors are most often found in young adults and tend to run a progressive course.
3. They most frequently involve soft tissues in the region of the knee, foot, thigh, ankle, hand, and elbow.
4. Their roentgenologic diagnosis is suggested by the presence of (a) a homogeneous soft-tissue mass near a joint (this mass usually has sharp borders and is occasionally lobulated); (b) irregular calcification within the tumor (in more than one-third of the cases); (c) secondary invasion of contiguous bone (in approximately one-third of the cases).

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(Para el sumario en español, véase la página siguiente.)

SUMARIO

Las Manifestaciones Roentgenológicas del Sarcoma Sinovial

Los sarcomas sinoviales son neoplasias malignas relativamente raras que suelen asociarse con los tejidos revestidos de sinovia. Obsérvanse más a menudo esos tumores en jóvenes adultos y suelen mostrar una evolución progresiva. Afectan con la mayor frecuencia los tejidos blandos de la región de la rodilla, del pie, muslo, tobillo, mano y codo. Sugiere el diagnós-

tico roentgenológico de los mismos la presencia de: (a) una masa de tejido blando homogéneo cerca de una articulación (esa masa suele tener bordes agudos y es a veces lobulada); (b) calcificación irregular dentro del tumor (en más de la tercera parte de los casos); (c) invasión secundaria del hueso contiguo (aproximadamente en la tercera parte de los casos).



Angiography in the Evaluation of Intracranial Trauma¹

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ANGIOGRAPHY in the diagnosis of intracranial lesions is not a new procedure, having been developed in 1927 by Egas Moniz (2). The technic has not been widely applied, however, in the evaluation of intracranial mass lesions occurring as a result of trauma. Many surgeons have preferred to depend upon watchful waiting, with the employment of a trephine as indicated. Under this type of management the diagnostic error has been high (30 to 40 per cent). In an attempt to reduce this figure, we have been utilizing carotid arteriography with increasing frequency since 1949.

Approximately 1,000 head injury patients are seen on the neurosurgical services of the Detroit Receiving, Detroit Memorial, and Grace Hospitals each year. About one-half of these present evidence of severe intracranial damage. It is in this latter group that angiography has been useful in determining the presence of intracranial hematoma, its extent, and its localization. In previous reports on this subject, 30 cases studied by angiography were reviewed (3, 4). The accuracy of the findings was established, and the method seemed to warrant further use. Since these earlier reports, a total of approximately 500 carotid arteriograms have been obtained. The method has proved a valuable clinical aid to early and accurate diagnosis.

EXPERIMENTAL MATERIAL

A challenging diagnostic problem confronts the radiologist in interpreting cerebral angiograms. For the purpose of obtaining more knowledge of the vascular patterns produced by intracranial hematomata, studies were carried out on cadaver

material (1). A radiopaque injection medium composed of barium sulfate powder added to a suspension of red lead and laundry starch was injected into the arterial system of embalmed cadavers, permitting visualization of the smallest arteries visible on gross dissection. Adequate vascular patterns were obtained in six instances, so that the roentgenograms could be utilized for subsequent evaluation following the creation of artificial mass lesions.

An intracranial mass was produced by tapping the calvarium and injecting a lipid material in the form of vegetable shortening (Spry or Crisco) into the epidural space. Serial roentgenograms were made after the injection of each 30 c.c. of the material in various areas over the cerebrum and in one instance over the cerebellum.

RESULTS

Though the masses produced by experimental means were epidural in location, they simulated subdural hematomata in that they were greater in the antero-posterior diameter, tending to dissect superiorly toward the mid-line. In spite of the difference between the living brain and the semisolid consistency of the fixed cadaver brain, a remarkable similarity in vascular pattern was found to exist between the artificially created mass lesions and those encountered following cranial trauma.

Temporal Area: The initial separation of the branches of the middle cerebral artery from the inner table of the skull occurred after the injection of 30 c.c. of the mass-producing medium. Larger volumes produced an increasing elevation of

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Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13-18, 1953. Completed for publication in August 1955.

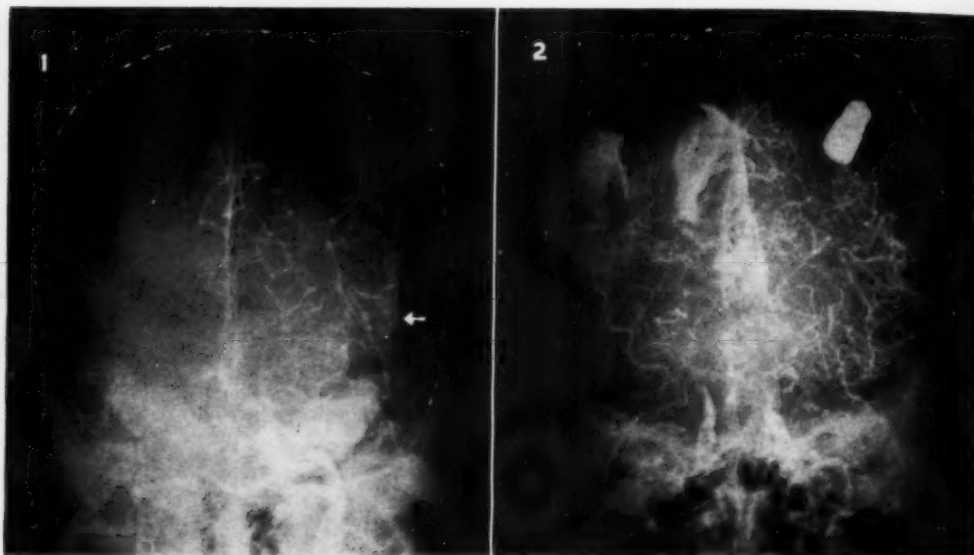


Fig. 1. A 90-c.c. mass produced by epidural injection, showing the dissection of the mass superiorly, with displacement of the peripheral branches of the middle cerebral artery away from the inner table of the skull and a definite flattening of the arc of the various segments. The anterior cerebral artery shows no significant displacement in spite of the relatively large epidural mass in the temporal area.

Fig. 2. Epidural mass (60 c.c.) produced over the frontal area. Bowing of the anterior cerebral artery is noted, and there is an inferior displacement of the terminal branches of the middle cerebral artery.

the middle cerebral group consistent with the findings encountered in clinical material. Of significance was the minimal or relative absence of shift of the anterior cerebral artery in frontal projections in the presence of subtemporal mass lesions (Fig. 1).

Frontal Area: In the second instance the mass was created over the frontal area just posterior to the coronal suture. Following the initial injection of 30 c.c. of the mass material, there was demonstrated bowing of the anterior cerebral artery and a beginning depression of the terminal branches of the middle cerebral artery. These early findings were seen only in the Towne projection, and it was not until an increased mass was present that the displacements were visualized in the lateral projection. This becomes important in a consideration of the estimation of volume of mass lesions in this area (Fig. 2).

Parietal Area: Masses were injected in both anterior and posterior parietal regions. The characteristic patterns showed a shift of the middle cerebral branches

away from the inner table of the skull. With increase in the mass, the anterior cerebral group was also shifted. The shift was more prominent and occurred earlier with masses located anteriorly (Fig. 3A) than with posterior parietal masses, in which the anterior cerebral artery maintained its mid-line position (Fig. 3B).

Occipital Lobe: When the mass was situated over the occipital lobe, the peripheral branches of the middle cerebral artery showed flattening and finally displacement inferiorly from the inner table. Though the appearance is similar, in the Towne projection, to that of masses situated in the frontal area, because of superimposition of anterior and middle cerebral branches, the absence of shift of the anterior cerebral artery across the mid-line provides the distinction (Fig. 4).

Cerebellar Area: We have been unable clinically to diagnose posterior fossa collections by means of either vertebral or internal carotid arteriography. A mass was created in the cadaver material in this

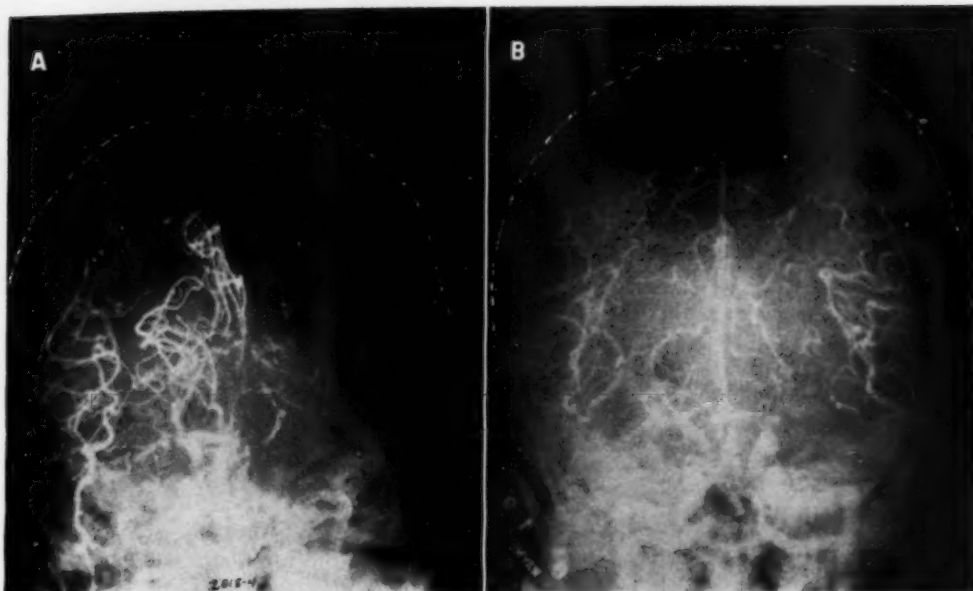


Fig. 3. A. Anterior parietal mass. Significant displacement of the branches of the middle cerebral artery away from the inner table of the skull and immediate bowing of the anterior cerebral to the contralateral side.

B. With a posterior parietal mass of the same volume as that in A, a similar displacement of the branches of the middle cerebral artery is noted. However, there is no displacement of the anterior cerebral artery until the posterior mass reaches rather large proportions.

area for further evaluation. No deformity of either the middle cerebral or posterior cerebral artery could be detected in spite of 85 c.c. volume of the material. This was substantiated upon opening the skull.

Incidental Finding: During the routine injections of the cadaver material it was found that a premortem mass lesion consistent with subdural hematoma existed. A similarity in volume and distribution of vascular elements to the postmortem lesions was established upon comparison of radiographs.

CLINICAL EVALUATION

1. *Early Diagnosis:* A history or clinical evidence of cranial trauma is not always obtained among patients admitted to a general hospital. Trauma may be incidental to alcoholism, a cerebral vascular accident, or conditions involving stupor or coma. By utilization of cerebral angiography, the diagnosis or exclusion of a surgical lesion has been possible without exploratory surgery (Fig. 5).



Fig. 4. Epidural mass produced over the occipital lobe, showing prompt displacement of the terminal branches of the middle cerebral artery inferiorly. The appearance is somewhat similar to the situation observed when the mass is produced over the frontal area except that the branches of the middle cerebral artery are more compact and again there is an absence of shift of the anterior cerebral artery with the posteriorly placed mass lesion.

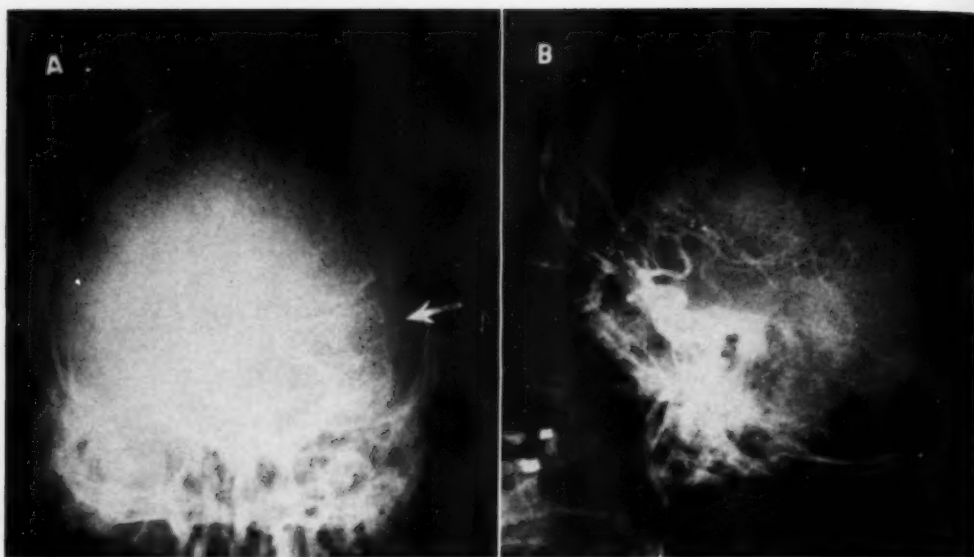


Fig. 5. A. Patient admitted to the hospital suspected of acute alcoholism. Prompt response to treatment was not obtained, and angiography was carried out, revealing displacement of the anterior cerebral well across the mid-line and a displacement of the branches of the middle cerebral artery away from the lateral aspect of the skull. B. Lateral view in same case, revealing a bunching of the branches of the middle cerebral artery with slight inferior displacement.

Diagnosis: Subdural hematoma, frontotemporal. A large collection was immediately evacuated and the patient responded at once.

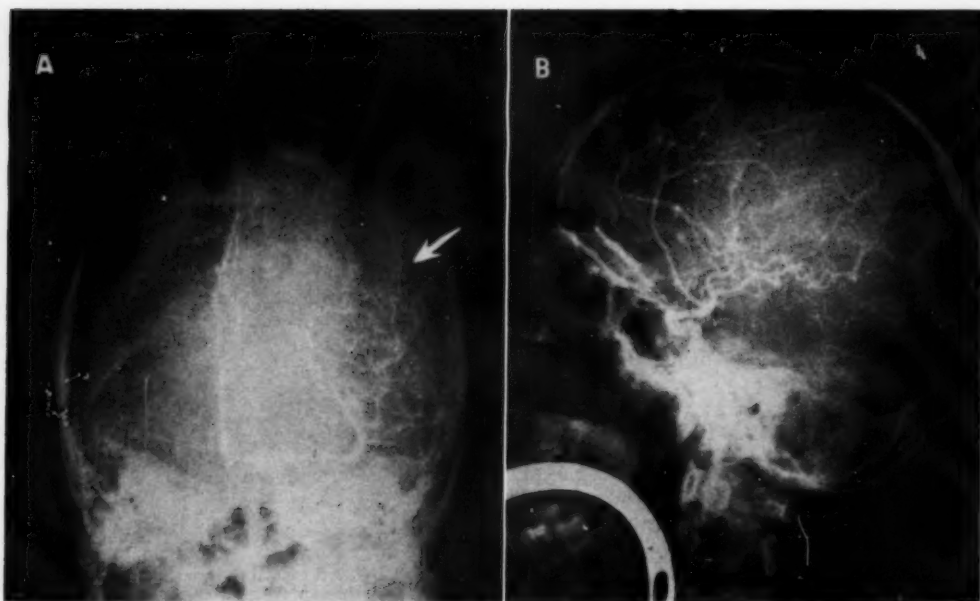


Fig. 6. A. Patient admitted unconscious, with indefinite history of injury. Angiography was accomplished promptly, revealing displacement of the middle cerebral group away from the inner table of the skull and a slight displacement of the anterior cerebral to the opposite side. B. Lateral view of the same patient, showing slight compression of the branches of the middle cerebral artery but little other specific displacement.

Diagnosis: Anterior parietal subdural hematoma. Drainage was instituted and the patient recovered.

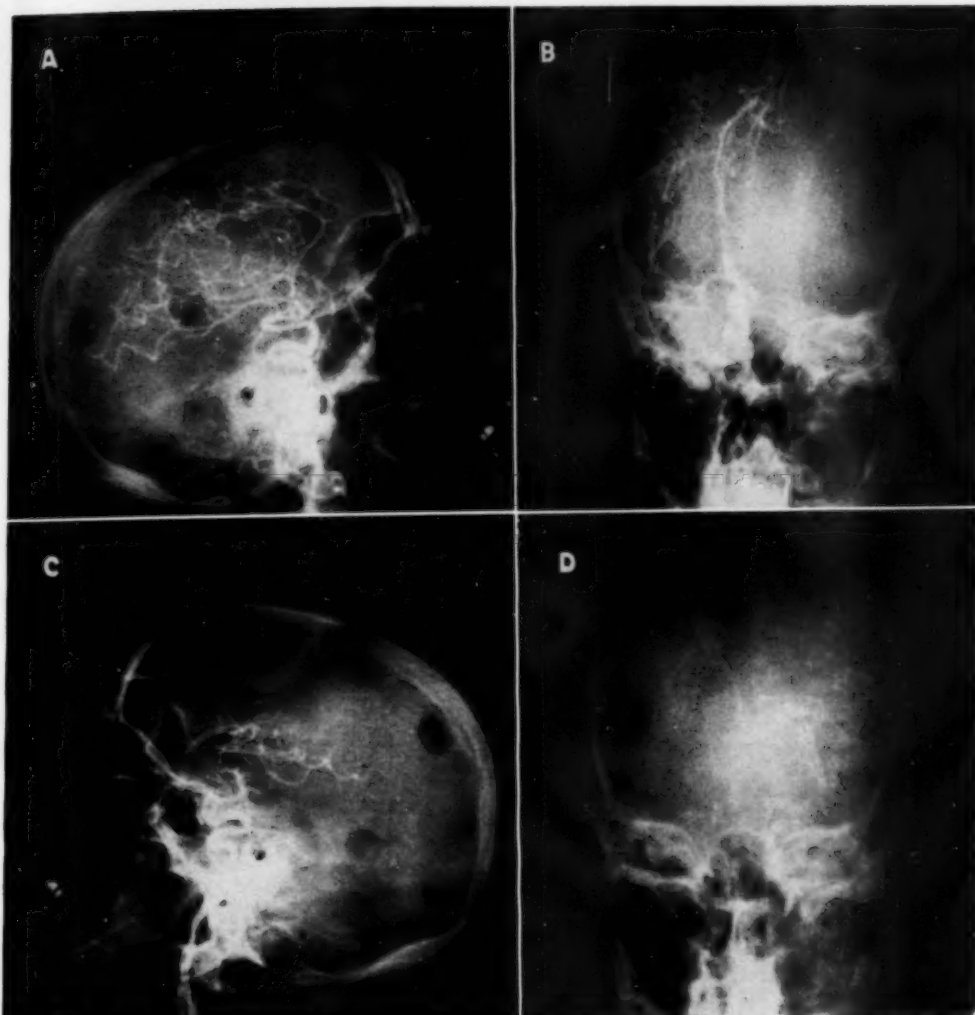


Fig. 7. A. Patient admitted with history of head injury, unconscious and failing to improve. Trephining was done in the parietal areas, with evacuation of a small amount of liquid hematoma. There was no response to this measure, and no localizing signs were present. Angiography was done forty-eight hours later, with injection first on the right side showing a normal arterial pattern in the lateral view.

B. Towne projection at this time indicates a mass lesion on the side opposite the filled arterial tree, as indicated by the ipsilateral displacement of the anterior cerebral artery.

C. Angiography on the opposite (left) side indicates a compression of the middle cerebral vessels with absence of filling of the anterior cerebral as seen in the lateral view.

D. In the Towne projection a definite displacement of the branches of the middle cerebral artery away from the inner table of the skull is demonstrated, extending from the temporal over the parietal region.

Diagnosis: Temporoparietal subdural hematoma, left side. Following drainage the patient recovered.

In some patients it has been possible by this method to establish the diagnosis of a mass lesion earlier than in the past and before the development of a critical clinical state with irreversible brain changes (Fig. 6).

2. *Lateralization:* Although in the majority of instances there is sufficient clinical evidence to indicate the side of involvement by a hematoma, there are frequent instances in which lateralization is not possible. Bilateral focal signs and findings

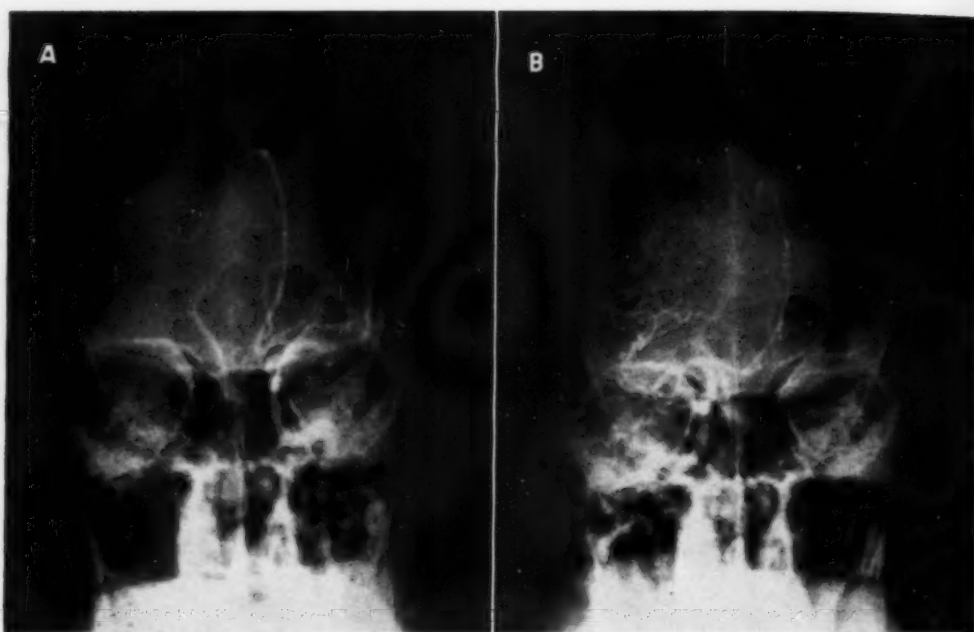


Fig. 8. A. Patient admitted with history of severe head injury, unconscious and with no local signs. A left carotid arteriogram demonstrates significant shift of the anterior cerebral artery to the ipsilateral side.

B. The right side was then injected. The marked displacement of the anterior cerebral to the left is demonstrated and there is also evidence of depression and medial displacement of the terminal branches of the middle cerebral artery.

Diagnosis: Frontoparietal subdural hematoma. Following surgery the patient recovered.

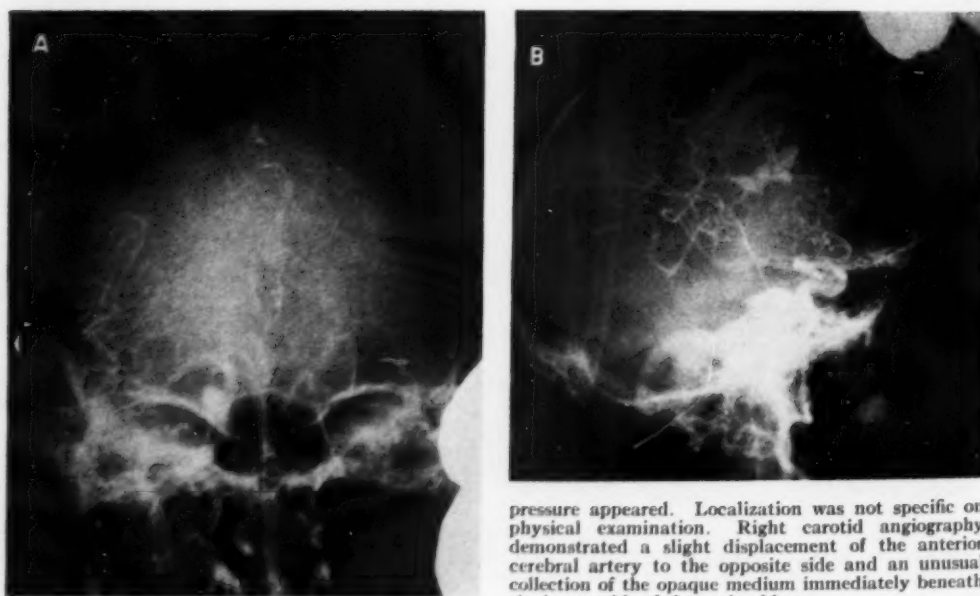


Fig. 9. A. Patient admitted with a history of a blow on the side of the head. Survey films demonstrated a localized comminuted fracture in the anterior right parietal region, with no depression. The patient failed to respond well and signs of increased intracranial

pressure appeared. Localization was not specific on physical examination. Right carotid angiography demonstrated a slight displacement of the anterior cerebral artery to the opposite side and an unusual collection of the opaque medium immediately beneath the inner table of the parietal bone.

B. Lateral projection showing local extravasation of the medium. There is a slight depression of the branches of the middle cerebral artery.

Diagnosis: Epidural hematoma, right frontoparietal. Drainage resulted in prompt recovery.

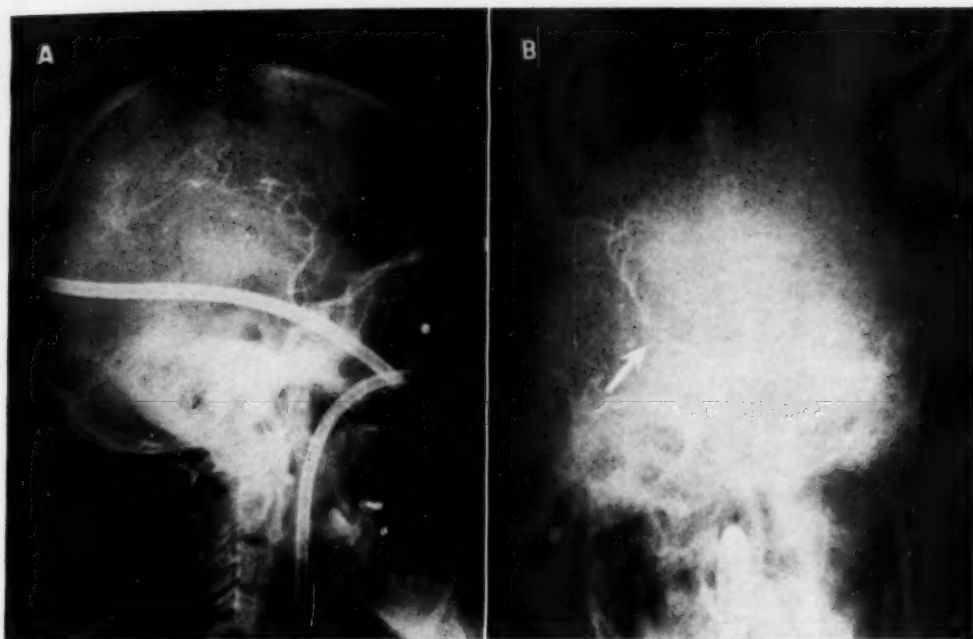


Fig. 10. A. Patient admitted with a history of head injury, unconscious and in serious condition, with progressive signs of increasing intracranial tension. Right carotid angiography revealed a marked elevation and medial displacement of the primary segment of the middle cerebral artery with the terminal branches approximating the inner table of the skull fairly well.

B. Lateral projection indicates a marked elevation of the primary segments of the middle cerebral artery. This is typical of a mass lesion in the temporal region.

Diagnosis: Probable subtemporal subdural hematoma with intracerebral clot. Surgical exploration revealed a moderate collection of liquid clot in the middle fossa and a 40-c.c. clot within the temporal lobe. Following evacuation, improvement was slow but the patient ultimately recovered.

which may implicate the wrong side lead to confusion. If exploration is carried out without preliminary angiography, numerous trephine openings may of necessity be made and even then the possibility of error exists. On several occasions the suspected side has proved to be free from involvement but the angiographic evidence foretold the findings by a shifted pattern of the anterior cerebral artery (Figs. 7 and 8).

3. *Localization:* Some of the diagnostic arterial patterns have been described above as a part of the correlation with the cadaver material. Such localizations are of importance and permit surgical removal of the collection with a well planned operation (Fig. 9). It is often possible to demonstrate the presence of an unsuspected intracerebral mass in addition to a subdural or epidural hematoma. A minimal

shift of the peripheral branches of the middle cerebral group away from the inner table of the skull with a significant superior displacement of the primary segment of the middle cerebral artery may indicate the presence of intratemporal lobe clot (Fig. 10). When trephining is carried out and only a small subdural collection is encountered, further search would be indicated. On several occasions, an additional large intracerebral collection has been evacuated. Also occasionally encountered is a widening between the middle cerebral and anterior cerebral groups as a result of a mass lesion in the deeper portions of the frontal lobe (Fig. 11). Parietal lobe intracerebral clots are usually of spontaneous etiology but may be identified by a typical pattern in the angiogram. A poor degree of filling of any major group of vessels (anterior or middle) in the acute

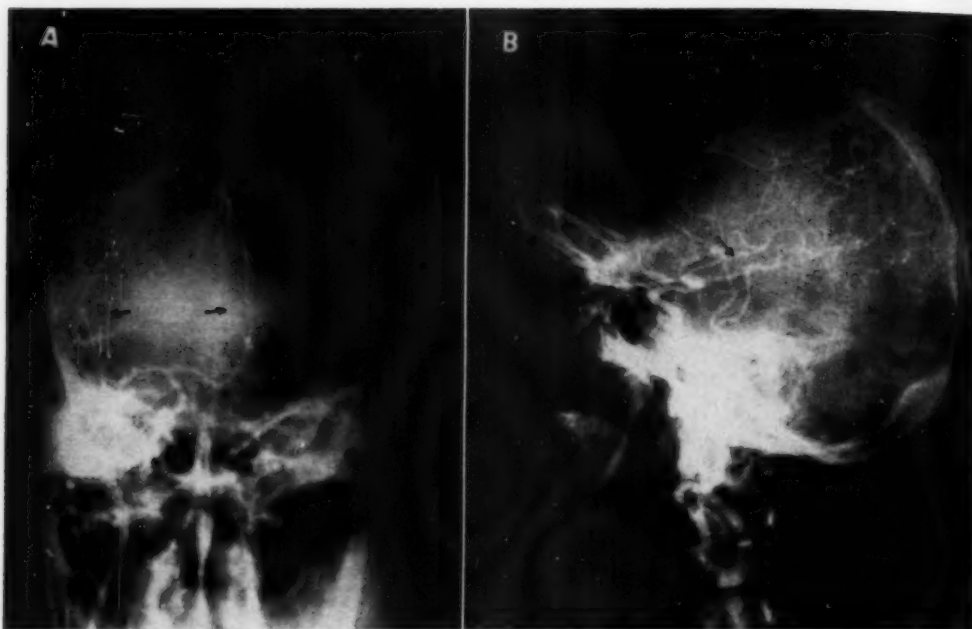


Fig. 11. Patient was picked up on the street, unconscious, with signs of serious intracranial disturbance. No specific history was obtainable. Lateralizing signs were evident. A right carotid angiogram in the Towne projection demonstrates a widening of the spacing between the anterior and middle cerebral groups. There is no evidence of subdural collection. The picture suggests a mass lesion in the frontal lobe. Exploration revealed a large intracerebral clot in the frontal lobe. This was evacuated and the patient ultimately recovered.

B. Lateral projection in the same case indicated some straightening of the primary branches of the middle cerebral artery with slight depression.



Fig. 12. A. Patient admitted two weeks previously with a history of head injury, with diffuse signs. Exploration was accomplished by means of trephine openings, with evacuation of a moderate liquid subdural hematoma over the right parietal area. The patient at first improved and then began to show signs of increasing intracranial tension. No specific localizing signs were present. Right carotid angiography demonstrates a slight displacement of the primary branch of the middle cerebral artery medially, but localization is not possible in the Towne projection.

B. Lateral projection demonstrating a very severe posterior and inferior displacement of the anterior cerebral artery, which is poorly filled. There is also a slight depression of the primary segment of the middle cerebral artery.

Diagnosis: Mass lesion, frontal area. Exploration, with flap, was carried out, revealing a massive epidural hematoma in the frontal area. The patient recovered.

case with associated displacements of vascular elements may indicate severe cerebral contusion or laceration (Fig. 12).

OTHER DIAGNOSTIC METHODS

Pneumoencephalography: Although pneumoencephalography may be employed for the diagnosis of any mass lesion, it has a disadvantage in the patient with an acute head injury. In the past, a ventriculogram was used to identify a lesion not found by trephine. The introduction of air and the radiographic examination which ensued were disturbing factors to the patient. When the findings were normal (33 per cent), only more injury had been added. Angiography may be carried out preoperatively in all of these instances with less disturbance to the patient, as well as greater accuracy in localization. In the occasional instance where non-filling occurs or injection is otherwise unsatisfactory, exploratory trephining can be employed.

Electroencephalography has been found to be inaccurate in approximately 50 per cent of patients. Particularly in the acute or subacute types of subdural hematoma, a mass lesion cannot be identified with certainty. The accuracy increases as the lesion becomes more chronic. Since bedside records can be made, the method is helpful.

SUMMARY

1. Experience encountered in an evaluation of cases of traumatic intracranial

hemorrhage over a period of four years in institutions in which approximately 1,000 such patients are admitted annually has been reviewed.

2. The appearance of artificially produced epidural mass lesions in cadaver material has been correlated with the findings in clinical material. This comparison indicates the reliability of angiographic findings to determine localization and volume of intracranial hematoma.

3. Representative roentgenograms have been presented to demonstrate the various types and locations of intracranial hematomata.

4. The utilization of carotid arteriography in the study of patients suffering from cranial injuries is reliable and substitutes a radiographic examination for an exploratory trephine operation.

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SUMARIO

La Angiografía en la Justipreciación del Traumatismo Craneal

En cuatro años de experiencia en hospitales que reciben anualmente unos 1,000 enfermos con lesiones cefálicas, la angiografía cerebral resultó ser un auxiliar valioso en el diagnóstico temprano y exacto del hematoma intracraneal. Con el propósito de obtener mayores conocimientos de los patrones vasculares producidos por esas lesiones en masa, los AA.

hicieron estudios en cadáveres en que se simulaban hematomas subdurales con la inyección de una sustancia lipida. Observóse una semejanza notable entre el patrón arterial descubierto en estos ejemplares y el observado a continuación de traumatismos craneales. Describense e ilustranse con grabados los hallazgos obtenidos con masas de sustancias intro-

ducidas en varias zonas (frontal, temporal, etc.).

A base de estas observaciones, dedúcese que la utilización de la arteriografía caró-

tida para la justipreciación de enfermos que padecen de lesiones craneales es digna de fe y emplea un examen radiográfico en vez una trepanación exploradora.

DISCUSSION

Paul C. Swenson, M.D. (Philadelphia, Penna.): Such an investigation as Doctors Lofstrom, Webster, and Gurdjian have carried out is always commendable, for it adds to our knowledge of what variations from the normal picture mean and thereby increases the accuracy of our interpretations. I read their paper with great interest. At their institutions they see a large number of head injuries and perhaps nowhere in the world is there a better opportunity for a close correlation between the clinical, radiologic, and experimental phases of this entity. Nowhere would there be a better chance to compare angiography, pneumography, and the clinical and operative findings.

I question only one point in their technic. I am a bit dubious about the material used to simulate the subdural hematoma. The authors have injected a lipid material into the epidural space. It occurred to me that the difference that existed between the experimental material used and the actual conditions in the living patient might make an appreciable difference in the effects produced, particularly when one thinks of the difference that exists between the living brain tissues and the fixed cadaver brain. The authors call attention to this last difference, but I think it should have a little more emphasis, since it is rather difficult to create an entirely comparable condition. Would not the experimental hematomas produced by a solid or semisolid material produce greater distortion than the soft hematomas in the living individual?

One other suggestion we might make is that there has been no correlation with the clinical identification of hematomas. This is not always easy, but it would be something worthwhile. (1) What percentage of error exists in clinical angiography in both extradural and subdural hematomas? (2) Granting the difficulty that has been noted in identification of the rare case of extradural hemorrhage in the posterior cerebral supply, how would one go about identifying such a rare case, or is it possible?

Some neurosurgeons and neurologists have ex-

pressed the opinion, to me at least, that when there is clinical suspicion of a hematoma, they consider an exploratory trephine less of a hazard and more definitive than the angiogram or an air study, particularly when there is the chance of missing the odd case and because, as one man put it, there is less hazard in doing a trephine than a *bilateral* angiogram. One would always have to check both sides to be absolutely certain. I think the authors will agree to this.

Such a work as the essayists have done is always stimulating and of great value to us all. It further narrows down the borderline of subroentgenographic conditions and should help keep everyone alert to better diagnostic results.

Dr. Lofstrom (closing): I am sure that if this were a neurosurgical group the discussion would be well pointed along the lines that Dr. Swenson has brought out. I know that there is a great deal of difference of opinion in the ranks of neurosurgeons as to the comparative value, or the comparative trauma to the patient, of this examination as opposed to trephination. I am sorry that I broke one slide a little bit ago; it showed an instance in which trephination had been done in three areas of the skull, a very minor collection having been evacuated on the right side. The patient went on with evidence of increasing difficulty, and by means of angiography it was then determined that there was a much larger collection anterior and inferior to the areas of the trephining. We have seen numerous instances of that sort.

We have also had cases in which removal of a mass lesion by trephining and drainage has been followed by a recurrence of hemorrhage and angiographic pattern has been of considerable assistance.

I realize that there is a distinct difference in the material used for the cadaver studies and the brain tissue in the living and I think one of the reasons for the relative similarity in displacement patterns is the compensation afforded by a more rigid brain.

Pulmonary Arterial Oligemia in Mitral Stenosis as Revealed on the Plain Roentgenogram¹

FELIX G. FLEISCHNER, M.D., and ELLIOT L. SAGALL, M.D.

DILATATION OF the pulmonary arteries, capillaries and veins, decreased velocity of the pulmonary circulation, and the imbibition of the parenchyma in mitral stenosis and other instances of pulmonary congestion have long been known, and their roentgenologic expression has frequently been described. Recently, however, our understanding of circulatory and hemodynamic conditions has been greatly enhanced by catheterization studies, angiography, and the impetus of cardiac surgery. In this report the plain roentgenogram in pulmonary congestion will be reinterpreted and an attempt made to correlate the findings with present concepts of the pathophysiology of the pulmonary circulation in mitral stenosis.

PRESENT CONCEPTS OF PULMONARY OLIGEMIA AND PLEONEMIA

The roentgen appearance of the congested lung is well known. In addition, certain vascular patterns have acquired practical diagnostic significance in the field of congenital heart disease. Pleonemia, *i.e.*, increased blood flow to the lung, and oligemia, or diminished blood flow to the lung, have been proposed as a basis, along with the presence or absence of cyanosis, of classification (Campbell, 1; Bing, 2). We have also learned to distinguish—with a fair degree of accuracy—between increased pulmonary blood flow and increased pulmonary arterial pressure (Healey *et al.*, 3; Campbell, 4).

Our experiences in the field of congenital disease, including both understanding of the morbid condition and its roentgenologic recognition, are applicable to acquired circulatory disturbances as well. Increased radiolucency of the lung fields, *i.e.*, oligemia, accompanied by enlargement

of the hilar shadows in advanced pulmonary emphysema has been known for a long time. The oligemic appearance of the lung in certain instances of pulmonary embolism without gross infarct formation is of more recent recognition (Westermarck, 5; Hanelin and Eyler, 6). The following classical description of the roentgenologic features of pulmonary congestion is based upon Zdansky (7) and Kerley (8). In the early phase of mitral stenosis, the vascular markings in the central portion of the lung and the hilar regions are more prominent. In the stage of pulmonary engorgement the lung markings are well defined and the lung fields are clear. The changes are attributed to passive congestion of the pulmonary veins. With increasing pulmonary engorgement, the work load of the right ventricle is increased, resulting in pulmonary arterial hypertension and progressive dilatation of the large arteries. The hilar shadows undergo further enlargement, the lung markings become broader, a fine network appears between the thicker vascular shadows, and these shadows lose their sharp contours. Definition becomes vague; it is "impossible to get a picture with good contrast." Conglomerate shadows surround the massive hilar shadows.

This intensification of the lung structures, as well as the diffuse darkening of the lung fields, is attributed to the increasing engorgement of the dilated pulmonary vessels, including the capillaries, and to the transudation into the pulmonary parenchyma. An important contribution to the general clouding is made by the engorgement of the perivascular, peribronchial, interlobular, and subpleural lymphatics, as well as the hilar and perihilar lymph nodes, which are filled with transudate.

¹ From the Departments of Radiology and Medicine of the Beth Israel Hospital and Harvard Medical School, Boston, Mass. Read before the New England Cardiovascular Society, Feb. 6, 1954. Accepted for publication in November 1954.

In another study, by Borden, Ebert, Wilson and Wells (9), pulmonary hypertension in mitral stenosis is described as causing "enlargement of the pulmonary arteries and a reticular and finely mottled appearance of the lung."

In these and other descriptions, neither

terial tree of the left lower lung field in a case of mitral stenosis with no dyspnea at all, Group I (A), and the altered arterial tree in a case of Group II with dyspnea on marked exertion (B) and in a case of Group III with dyspnea on moderate exertion (C). From these findings it is seen that

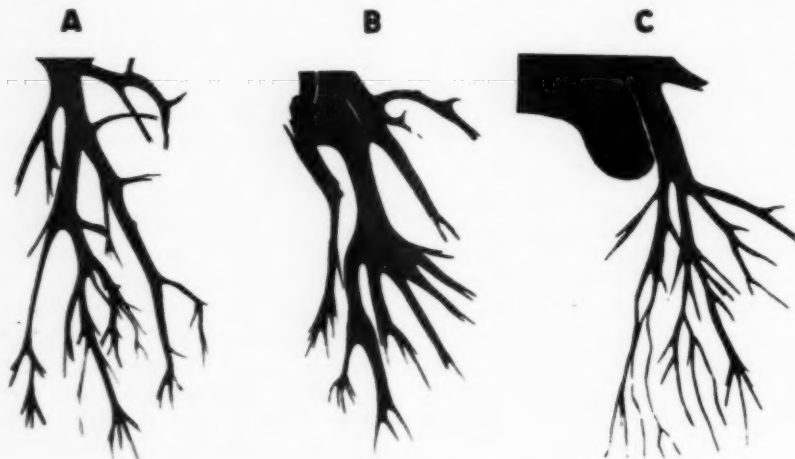


Fig. 1. Tracings from the left lower lung field in the pulmonary arterial phase of arteriography. A. Mitral stenosis, Group I: Relatively normal ramification of the lower arterial branches. B. Mitral stenosis, Group II: Early moderate changes with dilatation of the major branches and sudden narrowing of the peripheral branches. C. Mitral stenosis, Group III: Moderately advanced changes with marked dilatation of the main hilar arteries and narrowing and distortion of the branches of the third, fourth, and fifth order. From Goodwin, Steiner, and Lowe (10).

the pulmonary arteriosclerosis nor the pulmonary hypertension accompanying advanced mitral stenosis has found any immediate expression. Only hemosiderosis and disseminated nodular osteosis occurring in severe mitral valve disease have been recognized as specific features.

NEW ANGIOGRAPHIC OBSERVATIONS

Entirely new information has been obtained through the angiographic studies of Goodwin, Steiner, and Lowe (10), who demonstrated a marked narrowing of the pulmonary arteries of the third to the fifth order in mitral stenosis. This change was more pronounced in the clinically more severe cases characterized by dyspnea on moderate exertion and at rest. The diagrams from Goodwin and his co-workers (Fig. 1) represent the normal ar-

terial tree in advanced, functionally significant mitral stenosis—marked dilatation of the large hilar arteries accompanied by marked narrowing of the medium-sized branches of the pulmonary arteries. Actis-Dato, Angelino, and Zambelli (11) published similar observations.

THE AUTHORS' APPROACH TO THE PROBLEM

We asked ourselves whether it was possible to establish these changes on the plain chest roentgenogram without opacification of the arteries. At first this seemed hopeless, for two reasons. First, in all other known instances of oligemia, congenital and acquired, the diminished flow of blood to the lung results in a reduced blood content of the entire organ because there is no further barrier. The lung then appears bright on the roentgenogram.

In mitral stenosis, however, in accordance with the findings of the authors cited above, the oligemia on the arterial side is associated with stasis and congestion in the capillary area and on the venous side because of the impaired drainage into the overfilled left auricle. Thus, partial arterial oligemia would not be immediately recognizable against the background of capillary and venous pleonemia. Apparently this is why it has not been recognized before.

The other difficulty consists in the generally parallel arrangement of the arteries and veins in the peripheral lung field. Fortunately, however, the course of the larger vessels close to the hilus is totally different for each artery and vein. Assmann (12) early recognized on the plain roentgenogram the venous trunks converging from the right and left toward the left atrium, and crossing the tail of the arterial hilar shadow in a more or less horizontal course. The different arrangement of the arteries and veins was brought into better relief by laminagraphy, post-mortem opacification of the vessels, and eventually by the arterial and venous phases of angiocardiology. The hilar shadows—the more exposed right shadow in particular—are often compared to a comma, the tail of which is almost exclusively made up of arteries. This separation of the pulmonary veins from the larger arteries also enabled us, in an earlier study (13), to record electrokymographically the pulsation of the pulmonary veins in the right paracardial area (Fig. 2).

From a review of chest roentgenograms of patients with severe mitral stenosis, it became evident that the right hilar and paracardial region especially revealed features closely corresponding to the angiographic changes demonstrated by Goodwin *et al.*

PULMONARY ARTERIAL OLIGEMIA IN MITRAL STENOSIS AS MANIFESTED ON THE PLAIN ROENTGENOGRAM

We attempted to eliminate possible misinterpretation of individual variations

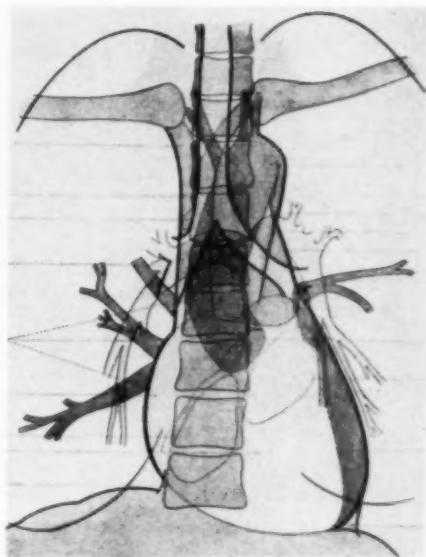


Fig. 2. Tracing of a normal chest roentgenogram (from Zdansky). The course of the lower pulmonary arterial branches on the right (lightly shaded) is clearly distinct from the convergent pulmonary veins (darkly shaded).

in the pulmonary vascular pattern and tried better to define the morbid pattern by long-term observations on subjects from a normal condition, or asymptomatic stage, to advanced circulatory disturbance. Roentgenograms indicating alveolar or interstitial extravasation of fluid were rejected; only those taken in a stage of fair compensation, depicting a "dry lung," were acceptable for this comparative study. For this reason, also, roentgenograms of advanced cases with intractable pulmonary congestion had to be excluded. Thus, of 67 patients with mitral stenosis followed for four to fifteen years, in and out of the hospital, only 10 had a roentgenographic record sufficiently long and qualitatively satisfactory to be used in this analysis. The experience first acquired from this long follow-up study has been broadened by review and roentgen-clinical correlation of numerous additional instances observed over a shorter period, by individual post-mortem arterial injections, and lung biopsies obtained during mitral valvuloplasty. The clinical grading used is according to the

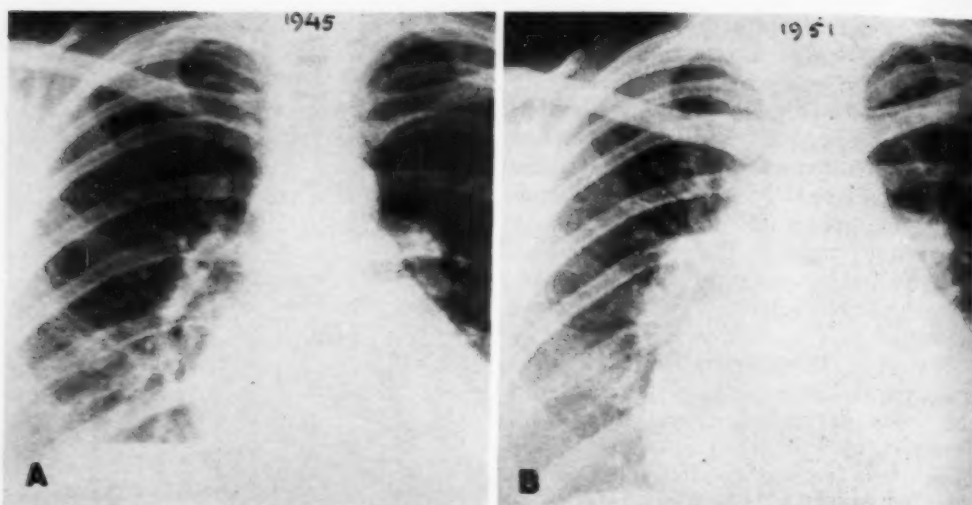


Fig. 3. Case I: Mitral stenosis. A (1945). Almost normal hilar arteries and slightly dilated vessels (? arteries and veins) in the lower lung fields. B (1951). After marked clinical deterioration. The right hilar arterial shadow is plump and tumor-like, extending downward, with disproportionately narrow, irregular branches.

criteria of the New York Heart Association (14): *Class I*, no limitation of physical activity. *Class II*, slight limitation and dyspnea on severe exertion. *Class III*, marked limitation even with moderate physical activity. *Class IV*, inability to carry on any physical activity without discomfort; dyspnea, etc., even at rest.

Some of these patients had more than 20 roentgen examinations over many years. Three cases are briefly presented.

CASE REPORTS

CASE I: Bessie S., born in 1903, had her first attack of rheumatic fever in 1914 and suffered relapses in 1919 and 1934. Though a heart murmur was heard in the early stages of the disease, she remained asymptomatic until 1945, when she experienced chest pain, cough, and hemoptysis. Mitral stenosis and insufficiency were diagnosed at that time. In 1951, after several episodes of congestive failure, she became seriously incapacitated, with dyspnea, orthopnea, palpitation, and paroxysmal nocturnal dyspnea. Systolic and diastolic apical murmurs and a low systolic pulmonic murmur were heard. P_2 was split and louder than A_2 . The liver was enlarged and the ankles were edematous.

This patient had her first symptoms at the age of forty-two (1945). Mitral insufficiency and systemic hypertension were dominant in the early phase, while mitral stenosis developed to a severe degree later. The roentgenogram of 1945 (Fig. 3A) showed moderate generalized dilatation of the heart. The right

hilar vessels were slightly dilated but were regular in shape and distinctly outlined, with the bronchial air space between cardiac silhouette and arterial hilar vessels clear and the tail of the hilar shadows splitting evenly into its branches. The lung fields were of normal brightness. Six years later (Fig. 3B), the heart had become bigger and spherical in shape. The hilar shadows were large, plump, and irregular in contour. The bronchial interspace on the right was obscured. Instead of regular lower arterial branches, disproportionately narrow, irregular fringe-like streaky shadows were seen arising from the lower pole of the right hilar shadow. The lung fields were gray and on the original roentgenograms one could see minute, irregular, spotty, and reticular shadows. This is the roentgenologic manifestation of the changes in pulmonary circulation from an early Class II stage to an advanced Class III stage.

CASE II: Lena M. C., born in 1901, had rheumatic fever in 1909 and chorea in 1911. Mitral stenosis and aortic insufficiency were diagnosed in 1930. Only a few clinical data are given in this instance to parallel the roentgenologic observations over fourteen years.

In 1939 (Fig. 4A), there was already a ten-year history of episodes of dyspnea and one episode of hemoptysis. The heart was triangular in shape and the right ventricle and left atrium were dilated. The hilar arteries were dilated but distinct as individual vascular structures. Episodes of congestive failure and hemoptysis occurred in the following years. In 1944, the right hilar shadow was a rather plump solid mass (Fig. 4B). In 1952, the venous pressure was 200 mm. H_2O , the circulation time fifty-two seconds (Decholin). There were atrial

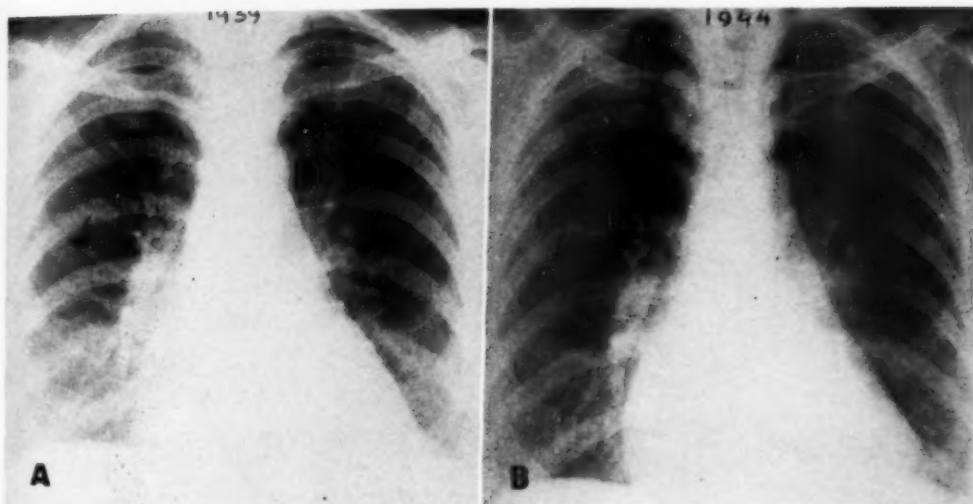
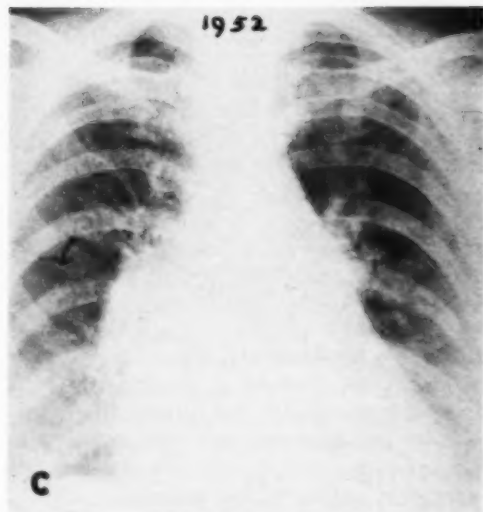


Fig. 4. Case II: Mitral stenosis. A (1939). Moderate dilatation of the hilar arteries and their downward branches. B (1944). More marked dilatation of the hilar shadows with blurring of individual vessels. C (1952). Plump, tumor-like hilar shadow; the downward branches narrow and hardly recognizable. These changes are accompanied by enlargement of the heart, more marked prominence of the pulmonary artery on the left, and generalized pulmonary congestion.

fibrillation and a loud P_2 (Fig. 4C). The pulmonary artery had become more prominent on the left, and the right hilar shadow appeared as a plump, homogeneous mass with a disproportionate, inconspicuous tail. Here again, dilatation of the large hilar branches and the disappearance of the arterial branches of the third to the fifth order developed in strict parallelism with the clinical deterioration over fourteen years from a Class II to an advanced Class III stage.

CASE III: Lillian B., born in 1901, had no definite history of rheumatic fever or chorea but had had "heart trouble" since the age of twelve. Later there were episodes of pulmonary and systemic embolism, and atrial fibrillation persisted from 1933. Systolic and diastolic mitral murmurs and enlargement of the heart had been recorded since 1933. In 1940, P_2 was found to be accentuated. As early as 1936 the right hilar arteries were considerably dilated (Fig. 5A); in 1945, the right hilar shadow formed a plump solid mass (Fig. 5B), and in 1950 the tail of the right hilar shadow was cut away, "amputated" (Fig. 5C). The lesser interlobar fissure, indicated by the arrow, permits easy topographic comparison. During this development the heart became larger and the pulmonary artery more prominent.

In most of these cases the lower pole of the plump hilar shadow was indistinct.



In a few others, a sharp-edged "amputation" was visible. We are inclined to interpret this sharp edge as an optical summation effect, caused by the lower main branch of the right upper pulmonary vein. This vein, engorged like the other pulmonary veins, in some instances crosses the right hilar shadow at such a level and angle that it adds the sharp edge to the tailless lower end of the hilar shadow.

While Parker and Weiss (13) were of the opinion that in some instances pulmonary vascular changes were caused im-

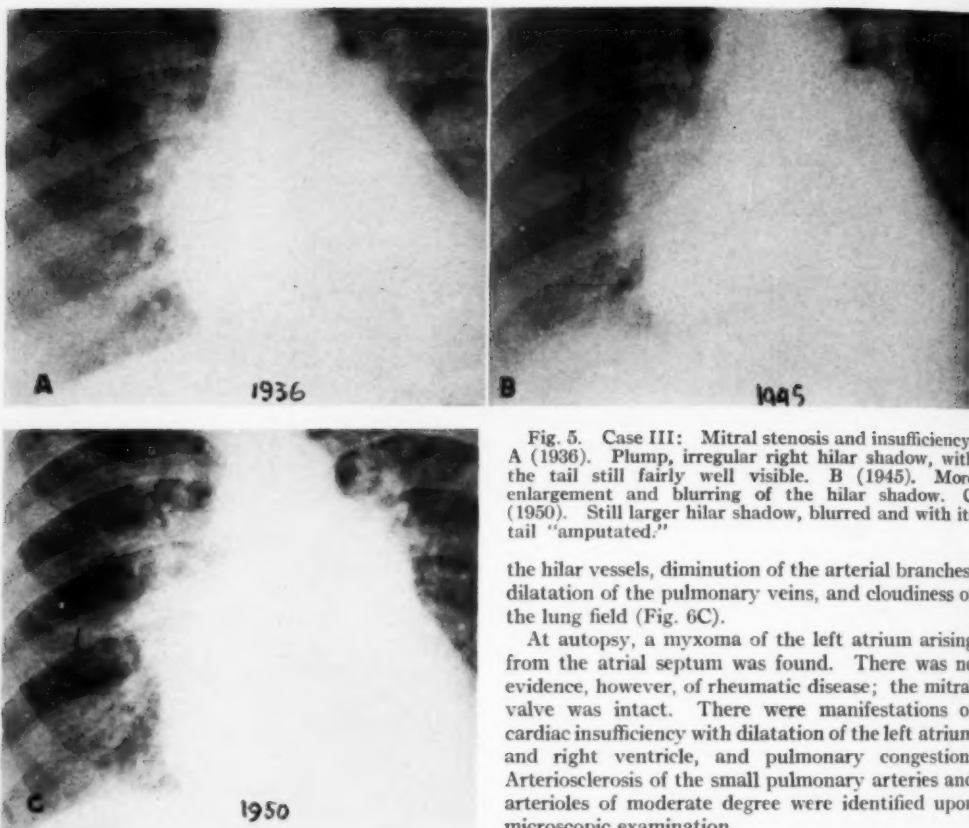


Fig. 5. Case III: Mitral stenosis and insufficiency. A (1936). Plump, irregular right hilar shadow, with the tail still fairly well visible. B (1945). More enlargement and blurring of the hilar shadow. C (1950). Still larger hilar shadow, blurred and with its tail "amputated."

the hilar vessels, diminution of the arterial branches, dilatation of the pulmonary veins, and cloudiness of the lung field (Fig. 6C).

At autopsy, a myxoma of the left atrium arising from the atrial septum was found. There was no evidence, however, of rheumatic disease; the mitral valve was intact. There were manifestations of cardiac insufficiency with dilatation of the left atrium and right ventricle, and pulmonary congestion. Arteriosclerosis of the small pulmonary arteries and arterioles of moderate degree were identified upon microscopic examination.

In this instance, the myxomatous tumor of the left atrium had caused hemodynamic disturbances similar to those of valvular mitral stenosis. Thus, the subsequent cardiovascular changes developed in a fashion identical with those of rheumatic mitral stenosis. Roentgenologically, there were progressive left atrial dilatation, pulmonary venous engorgement, right ventricular and pulmonary arterial dilatation with dilatation of the hilar branches, and constriction of the pulmonary arteries of the third to fifth order. This resulted in the picture of arterial oligemia.

In some instances, we have observed partial return to the normal vascular pattern after successful valvuloplasty, paralleled by clinical improvement. The following is an example.

Marion H., born in 1903, classified as having mitral stenosis, Group III, had a plump, bulging hilar

mediately by rheumatic disease, the general tendency at present is interpretation of vascular changes as the result of hemodynamic disturbances independent of the underlying etiology. The following observation supports this reasoning.

CASE IV: Arthur R., born in 1926, underwent a routine health examination in 1948, without clinical or roentgenologic evidence of disease of the heart or lung. In 1950, dyspnea on effort appeared, and within a month there was evidence of congestive heart failure and mitral stenosis, without a history of rheumatic fever. The condition became worse during the following two and a half years and, despite all therapeutic efforts, death occurred in the spring of 1953, after a terminal course of progressive congestive failure seemingly due to active rheumatic fever with mitral stenosis. The roentgen observations seemed to support this clinical assumption: a normal heart and hilar shadow in 1948 (Fig. 6A), the arterial and venous engorgement in 1951 (Fig. 6B), and the final stage of tumor-like plumpness of

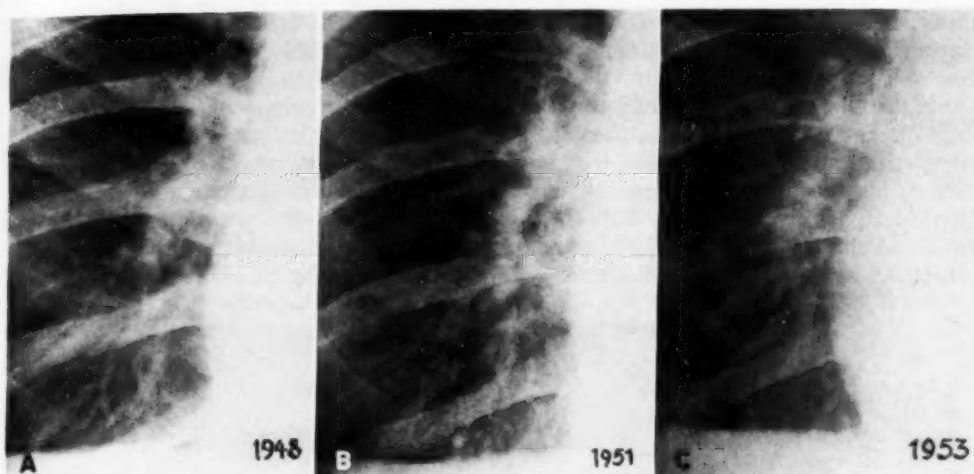


Fig. 6. Case IV: Myxoma of the left auricle, clinically and roentgenologically simulating rheumatic mitral stenosis. A. Normal hilar and peripheral vascular pattern at a routine health examination. B. One year after onset of the disease: engorged hilar arteries, narrowed tail arteries. C. Two months before death: plump hilar arteries. The arteries of the third to fifth order are almost invisible.

shadow and relative oligemia in the right paracardial region in November 1952 (Fig. 7A). Valvuloplasty, performed on Jan. 24, 1953 (Dr. Harken), was followed by cardiovascular improvement. Fourteen months later, the right hilar arteries appeared normal and had relatively normal branches extending downward (Fig. 7B).

DISCUSSION

The morphologically fixed pulmonary vascular changes in severe mitral stenosis with chronic pulmonary congestion have been thoroughly restudied in recent years (Parker and Weiss, 15; Larrabee, Parker, and Edwards, 16; Henry, 17). Arteriosclerosis of the arterioles and small arteries, with marked luminal narrowing, has been frequently found. Changes of the medium-sized arteries (about 1 to 5 mm. diameter) are rarely seen, while arteriosclerosis of the large hilar arteries is rather common. Pulmonary artery catheterization revealed arterial pressures much higher than one would expect from the barrier erected by the stenosed mitral valve and the vascular alterations. It was suggested, therefore, that a part of the disproportionately high pulmonary artery resistance, associated with or provoking the unusual pressure increment, might be due to arteriolar constriction, thus permitting change and

reversibility (Dexter *et al.*, 18, 19; Gorlin *et al.*, 20). The studies of Goodwin and his associates (10) demonstrated the presence and the site of arterial constriction. Notwithstanding the possibility of additional hypothetical arteriolar constriction, these studies demonstrated that the arteries of the third to fifth order, *i.e.*, of a caliber of approximately 2 to 5 mm., are narrowed and may appear tortuous and irregular. Furthermore, a good correlation was found between the existence and degree of these arterial changes and the pulmonary arterial pressure as measured by catheterization. Even the plain roentgenograms revealed corresponding vascular changes in instances of more severe pulmonary hypertension (Davies *et al.*, 21; Steiner and Goodwin, 22). (These latter publications appeared following the independent completion of our investigation.)

In the present study, the attempt was made to eliminate possible individual variations in the pulmonary vascular pattern and to define more clearly the morbid pattern by observing subjects from a normal condition or asymptomatic stage to advanced circulatory disturbance.

Patients of Group I ordinarily show no abnormal vascular pattern. The arterial

hilar shadows and their branches taper down in a proportionate fashion; their course is straight or evenly curved. Often the right lower and occasionally the upper pulmonary veins can be identified in the right paracardial field. The peripheral lung fields are clear. In some instances, there is possibly some borderline dilatation of the hilar and peripheral vascular structures in a proportionate fashion.

A good deal has been learned in the last few years about pulmonary circulation, pulmonary hypertension, and cor pulmonale. Anatomic narrowing of the vascular bed in pulmonary emphysema, pneumoconiosis, fibrosis, and the sudden vascular obstruction in pulmonary embolism undoubtedly play a direct part in raising the pulmonary arterial resistance. Clinico-pathological correlation suggests

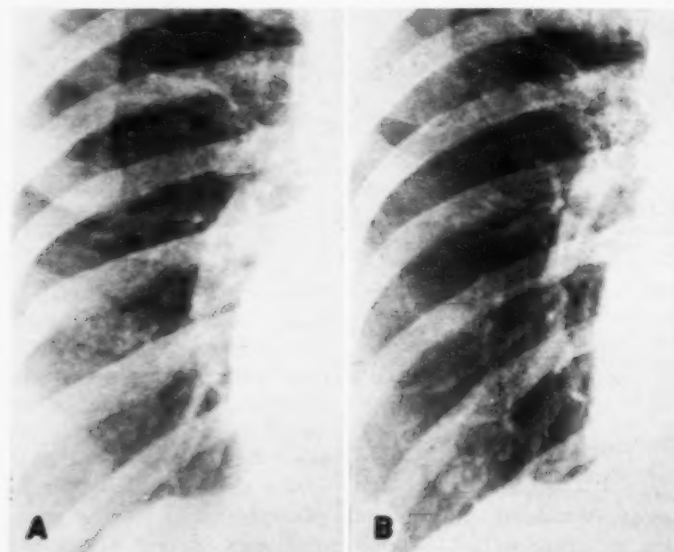


Fig. 7. Mitral stenosis. A. Preoperative film (November 1952) showing plump hilar shadow with convex contour, *i.e.*, dilated hilar arteries, with branches hardly visible. A fine nodular-reticular pattern spreads over the entire lung field. B. Postoperative film (March 1954). The hilar shadow is normal in width and lateral contour; the arterial ramification, especially into the hilar "tail," is relatively normal. The fine granularity of the lung field has disappeared.

In Group II, one usually observes moderate to marked dilatation of the arterial hilar shadows and proportionate dilatation of the arterial branches forming the tail of the right hilar shadow (Fig. 4B). The pulmonary veins, if distinguishable, are wider than normal. There is, in addition, faint general haziness, particularly in the lower lung fields, and often a delicate reticular pattern. All these changes are only slightly prominent and their definite recognition and proper interpretation depend largely upon the known presence of a mitral heart as determined by clinical and roentgenologic evidence.

that some of the clinical manifestations of these conditions are the result of functional changes, reflexes involving the pulmonary vasculature, the neurogenic mechanism of the heart, the peripheral vascular system, and the respiration. Much is still unknown about the finer mechanisms involved in these conditions. Many students, however, agree that the cases of mitral stenosis with disproportionately high pulmonary arterial pressure are closely analogous, in their pathophysiology, to other instances of cor pulmonale. Some authors, indeed, classify cases of mitral stenosis with pulmonary arterial hyper-

tension and marked right ventricular hypertrophy as a subgroup of cor pulmonale, thus contradicting, to a certain degree, the original definition of that term. While the coincidence of narrowing of the arterial lumen, increased resistance to flow, hypertension, and pulmonary arteriosclerosis appears to be established by observation, the causal relations of these manifestations are still hypothetical. One cannot deny their similarity to conditions described as primary pulmonary hypertension (23), cor pulmonale caused by pulmonary embolism (24), and the thrombo-embolic pulmonary vascular sclerosis attributed to *in vivo* flocculation in the blood (25, 26). Furthermore, in the mutual regulatory play of resistance, pressure, and flow, it is believed that a reflex constriction of the arteries and arterioles may protect the capillaries from too high a pressure, thus preventing the leakage of edema fluid (Dexter *et al.*, 19; Eliasch, 27; Edwards and Burchell, 28).

The possibly beneficial effect of arterial constriction, however, is coupled with the deleterious consequences of an increased work load for the right ventricle. In Groups III and IV, with few exceptions, marked elevation of the pulmonary arterial pressure, right ventricular hypertrophy, dilatation, and eventually right-side failure occur. Though there were no catheter measurements of pulmonary arterial pressure in our cases, it appears from the observations of Goodwin *et al.*, Actis-Dato *et al.*, and the material presented here that the aggravation of the clinical condition characterizing Group III is usually accompanied by constriction of the medium-sized pulmonary arteries resulting in arterial oligemia of the lung and manifested by increased pulmonary arterial pressure.

In these observations, extending over several years, the marked bulging of the hilar vessels and the disappearance of the hilar-tail arteries paralleled clinical deterioration, such as fatigability, dyspnea on exertion, orthopnea, atrial fibrillation, and episodes of congestive failure.

The hilar shadows are large and plump.

Often only the right hilar shadow is seen distinctly on the routine postero-anterior roentgenogram, the left being hidden behind the dilated cardiovascular mass. Large vessels, however, not distinguishable as to their arterial or venous nature, converge toward the upper poles of the right and left hilar shadows. The lateral and lower contour of the right hilar shadow stands out distinctly because of the absence of continuing vascular branches; the tail of the right hilar shadow is absent. Only narrow, tortuous vascular shadows are visible in place of the normal branches. The engorged veins, convergent toward the left atrium in a generally horizontal course, can be seen in the right paracardial field. Absence of the arterial branches sometimes becomes even more obvious when a branch of the right superior pulmonary vein, in its oblique downward course, crosses the lower pole of the hilar shadow, thus causing the impression of a flat cut-off or amputation of the latter. In addition, the entire lung fields show diminished translucency; they are occupied by indistinct, thin, tortuous vascular shadows and finely spotted densities, apparently the result of extravasated fluid, hemosiderin deposits, fibrosis, or both.

There are several reasons why we interpret the absence of the vascular shadows as caused mainly by functional vasoconstriction. If the arteriographic pictures of Goodwin and Actis-Dato were due to arteriosclerotic thickening of the vascular wall and consequent narrowing of the lumen, the overall width of the vascular shadow on the plain roentgenogram, representing the lumen (*i.e.*, blood column) and vascular wall, would not change. Furthermore, in a few instances we have observed return of the arterial vascular pattern after successful mitral valvuloplasty. Partial return occurred within three months after operation in one case, but more commonly one to two years are required, paralleling observations of post-operative fall of the pulmonary arterial pressure (Dexter, 18; Eliasch, 27). Moreover, severe arteriosclerotic changes of

the arteries of the third to fifth order have only exceptionally been recorded by the pathologists.

We attribute the more distinct recognition of this arterial constriction in the right paracardial region to different anatomic arrangements of the arteries and veins in that region, as explained above. Whether these changes are more marked in the dependent parts of the lung or occur evenly throughout the lung we do not know.

It is known, and in rare instances we have ourselves made the observation, that in severely incapacitated subjects with mitral disease of long duration the pathologist may find severe arteriosclerotic changes in medium-sized pulmonary arterial branches, not only with muscular hypertrophy but also with intimal fibrosis, the latter condition supposedly being irreversible. Though we have not been able to distinguish these irreversible changes roentgenologically from the more common reversible arterial constriction, it has been assumed that, as in essential systemic hypertension, an increase in vascular tone, vasoconstriction, precedes permanent structural changes. These observations lead to the conclusion that the appearance of arterial vasoconstriction manifested by a considerable rise of pulmonary arterial pressure, or more simply observed by arterial oligemia as shown on the roentgenogram, may indicate a turning point in the development of the disease. This, correlated with other clinical observations, may aid in determining the appropriate time for surgical intervention in order to prevent irreparable right-sided damage and irreversible arterial changes.

SUMMARY

Stimulated by reported angiographic observations of constriction of the pulmonary arterial branches of the third to fifth order in severe mitral stenosis, the authors reviewed the plain roentgenograms of subjects with mitral stenosis, followed them back for four to fifteen years, and

correlated the findings with the clinical course.

It was found that arterial narrowing can be recognized in the right paracardial region because of the different anatomic arrangement of the medium-sized arteries and veins in this region.

In the milder cases, the hilar and post-hilar vessels, including the arteries forming the tail of the right hilar shadow, become noticeably dilated but still branch in proportionate fashion. In more advanced cases, with severe limitation of physical activity, the right hilar shadow is plump; its constituent individual vascular shadows are fused and their contours are blurred. Instead of regular vessels forming the hilar tail, one may see thin, fringe-like streaks or no hilar tail at all.

This arterial oligemia of the lung is the roentgenologic manifestation of constriction of the medium-sized arteries and appears to be reversible for a certain period of time; the constriction is believed to precede irreversible arteriosclerotic narrowing of the vessels. Constriction and consequent arterial oligemia of the lung, recognizable on the plain roentgenogram, appear to coincide with—and may be responsible for—the disproportionate rise of the pulmonary arterial pressure in many advanced cases of mitral valve disease. Thus, arterial oligemia signalizes a turn in the development of the circulatory disorder, usually in the direction of deterioration. To recognize this arterial change may be an aid, along with other clinical facts, in determining the need for and timing of surgical intervention.

NOTE: We express our thanks to Dr. Leopold Reiner, acting pathologist, Beth Israel Hospital, for stimulating help and information on postmortem pulmonary arteriography.

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SUMARIO

La Oligemia Arterio pulmonar en la Estenosis Mitral según la Revelan las Radiografías Corrientes

Los AA. repasaron las radiografías corrientes de sujetos que padecían del estenosis mitral, mantuvieron a los últimos en observación durante cuatro a quince años y correlacionaron los hallazgos con la evolución clínica.

Observaron que cabe reconocer la estenosis arterial en la región paracardiaca derecha debido a la distinta disposición anatómica de las arterias y las venas de tamaño mediano en dicha región.

En los casos más leves, los vasos hiliares y posthiliares, comprendiendo las arterias que forman la cola de la sombra hilar derecha, se dilatan en forma advertible,

pero ramificándose todavía proporcionalmente. En los casos más graves, la sombra hilar derecha está "engordada"; las distintas sombras vasculares que la componen se confunden y los contornos de éstas están borrados.

Esta oligemia arterial del pulmón constituye la manifestación radiológica de la contracción de las arterias de tamaño mediano y parece ser reversible durante cierto período de tiempo. El reconocimiento de este cambio arterial puede ayudar, junto con otros datos, a determinar la necesidad de la intervención cruenta y el momento en que debe ejecutarse.

Bronchography in Diagnosis of Bronchogenic Carcinoma in Two Patients with Apparently Normal Chest Films¹

JUDAH ZIZMOR, M.D.

THE VALUE OF bronchography, in demonstrating partial or complete bronchial obstruction caused by carcinoma arising in the larger bronchi, has been stressed by Graham, Singer, and Ballon (6), Fariñas (5), Westermarck (15), and Di Rienzo (4), to name but a few. It is the purpose of this paper, first, to discuss the usefulness of bronchography in revealing bronchogenic carcinoma of the larger bronchi; second, to discuss the problem of the normal chest film in patients with bronchogenic carcinoma of the larger bronchi.

The bronchographic signs of bronchostenosis are easily understood if the appearance of the normal bronchial tree is kept in mind. The normal bronchial walls taper gradually and smoothly from the large bronchi to the periphery, and the bronchial branches maintain normal spatial relationships to each other. The signs of obstruction are usually easy to demonstrate and are often present when bronchoscopic findings are negative, as in neoplasms of the upper lobes. Even in cases which offer no radiographic problem in diagnosis, bronchography localizes the exact point of bronchial obstruction beyond the visual field of the bronchoscope.

In a recent report Zheutlin, Lasser, and Rigler (16) described pathognomonic bronchographic patterns for alveolar-cell carcinoma, namely, uniform diffuse narrowing of segmental bronchi in areas of lung involvement, bronchial rigidity and elongation, filling rather than coating of bronchi, and a lack of filling of terminal bronchioles and alveoli in segments supplied by these bronchi. Bronchographic evidence of bronchostenosis or occlusion may, however be associated with conditions other than bronchogenic carcinoma. Some of these are benign bronchial tumors, foreign bodies,

mucus plugs, inflammatory stricture or granulation associated with bronchiectasis or tuberculosis, hydatid cysts, and bronchial agenesis.

Bronchography is a safe office procedure when properly performed. In the investigation of obscure pulmonary disease, it serves a function similar to the gastrointestinal series, the cholecystogram, and the pyelogram in the study of abdominal disease. This point is illustrated by the following cases.

CASE I: F. H., a white male, aged 56 years, was admitted to the Manhattan Eye, Ear and Throat Hospital in October 1951, complaining of cough and expectoration and a weight loss of 8 lb. during the preceding three months. During the past month a wheeze had developed and the patient had begun to raise bloody sputum. He had no fever or chest pain. He had smoked one package of cigarettes a day for the past forty years. His previous history revealed two attacks of pneumonia in childhood and typhoid fever at the age of twenty-two.

On physical examination, some curving of the finger nails was observed, with slight increase of cyanosis of the nail beds. In the lower pole of the left lobe of the thyroid gland was a hard, round nodule 2.5 cm. in diameter. Examination of the chest revealed inspiratory and expiratory wheezes. The expiratory phase of respiration was increased. Respirations were 28 per minute, pulse 80, temperature 98.8° F. Conventional chest films (Fig. 1) disclosed old adherent pleurisy in the left chest, with straightening of the left diaphragm. The lungs were clear. The heart was in the mid-line and not enlarged.

Bronchography (Fig. 2) with Lipiodol instilled through a nasal catheter revealed a funnel-shaped constriction in the main stem bronchus of the right lung and puddling of oil above the constriction. The right main stem bronchus was involved to within 2.0 cm. of the carina and inferiorly to the points of origin of the right upper and lower lobe bronchi. Bronchoscopy was performed by Dr. Daniel Cuning, who found a constricting lesion of the right main bronchus. Biopsy showed highly anaplastic epidermoid carcinoma, Grade IV.

The patient was transferred to the Memorial Hos-

¹ From the Department of Diagnostic Roentgenology, Manhattan Eye, Ear and Throat Hospital, New York, N. Y. Accepted for publication in November 1954.

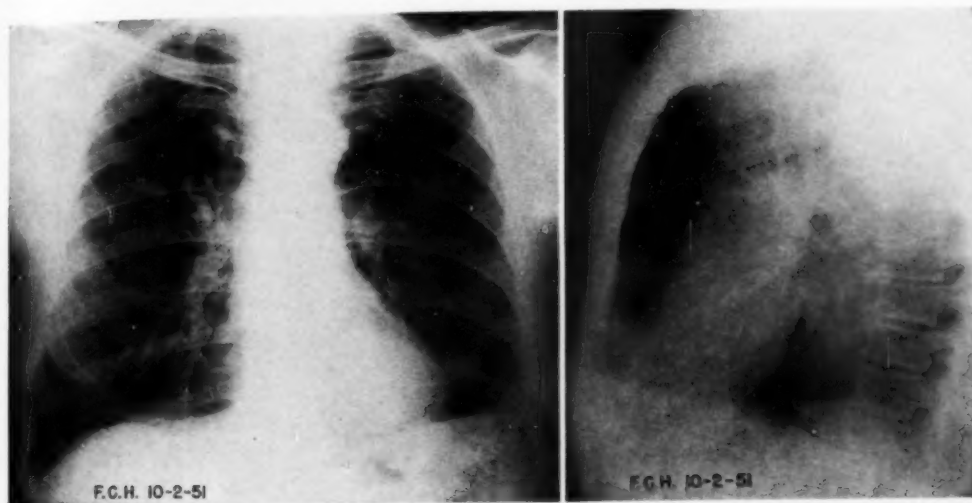


Fig. 1. Case 1. Conventional chest films.

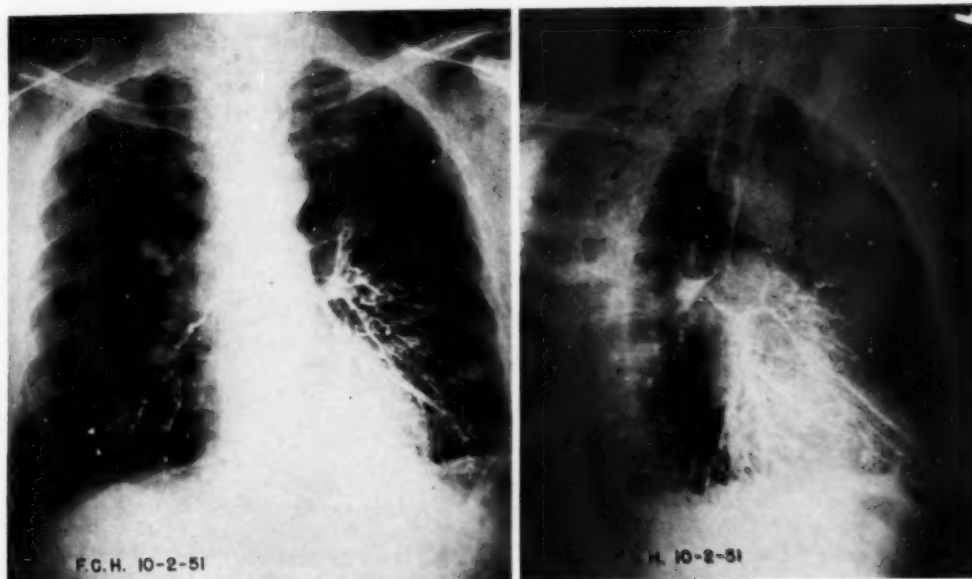


Fig. 2. Case 1. Bronchograms showing a constriction in the right main stem bronchus and puddling of the medium above the constricted area.

pital on Nov. 7, 1951. Bronchoscopy and exploratory thoracotomy were carried out on Nov. 15, in the hope that resection might be possible even though the disease appeared to extend to the carina. Operation disclosed infiltration of the right main stem bronchus, the underlying artery, and the mediastinum and aorta. Postoperative deep x-ray therapy was begun on Nov. 20 and completed Dec. 20, 1951. Following therapy the patient's weight increased from 146 to 160 pounds. Improvement was

maintained until March 1952, when he was again hospitalized because of liver metastases. The final diagnosis was carcinoma of the lung, non resectable.

CASE II: W. M., a white male, aged 50, was admitted to the Manhattan Eye, Ear and Throat Hospital on April 8, 1952. He gave a history of a slight productive cough for two months, with intermittently bloody sputum, and wheezing for two weeks. A year and a half before the onset of these

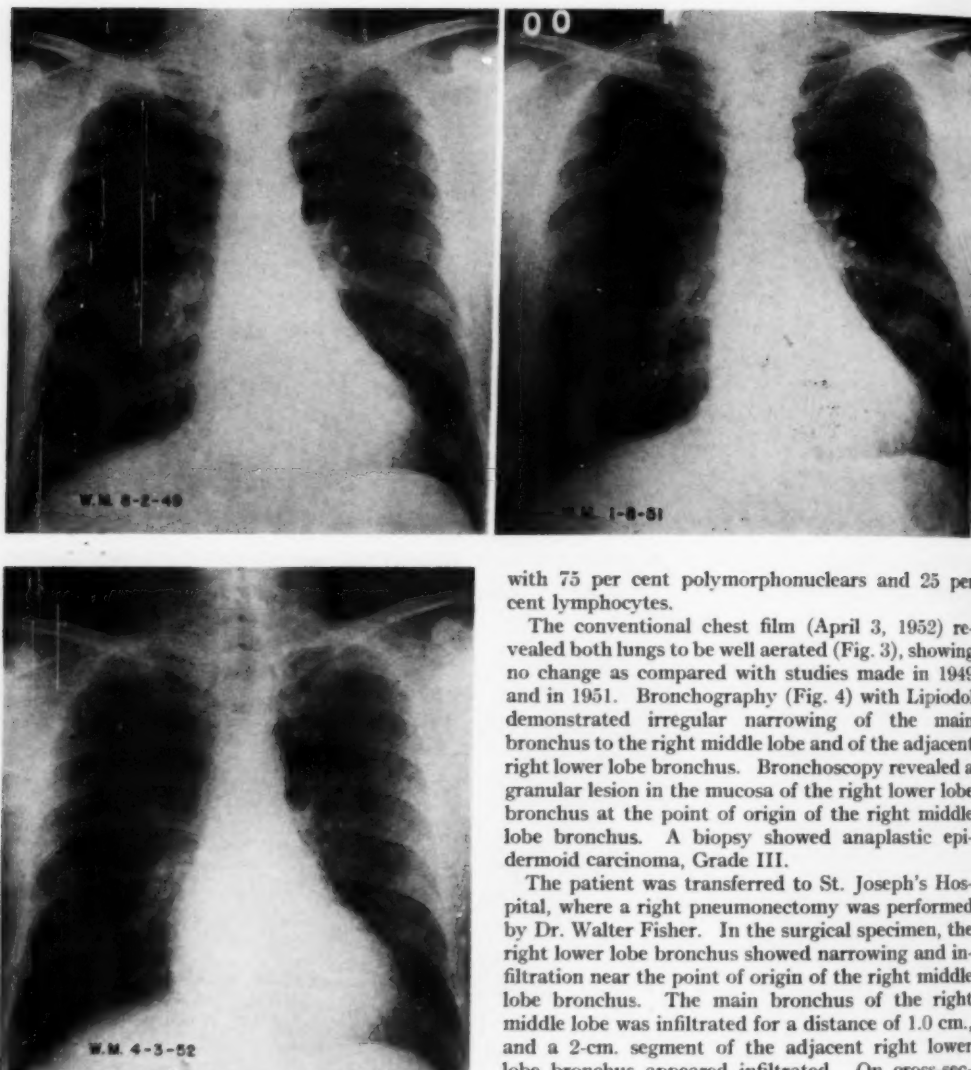


Fig. 3. Case II. Conventional chest films.

symptoms he had been ill for three weeks, with a low-grade fever and a mildly productive cough. A complete medical work-up, including chest films, failed to reveal the cause of this illness. It was assumed to be a virus infection. The patient had smoked one to two packs of cigarettes a day for thirty-two years. The only pertinent finding on physical examination at the present hospital admission was wheezing during inspiration and expiration, loudest over the right lower lung. The blood pressure was 120/80; pulse 82; respirations 22; temperature 98.6° F.; hemoglobin 88 per cent; red blood count 5,260,000; white blood count 12,125,

with 75 per cent polymorphonuclears and 25 per cent lymphocytes.

The conventional chest film (April 3, 1952) revealed both lungs to be well aerated (Fig. 3), showing no change as compared with studies made in 1949 and in 1951. Bronchography (Fig. 4) with Lipiodol demonstrated irregular narrowing of the main bronchus to the right middle lobe and of the adjacent right lower lobe bronchus. Bronchoscopy revealed a granular lesion in the mucosa of the right lower lobe bronchus at the point of origin of the right middle lobe bronchus. A biopsy showed anaplastic epidermoid carcinoma, Grade III.

The patient was transferred to St. Joseph's Hospital, where a right pneumonectomy was performed by Dr. Walter Fisher. In the surgical specimen, the right lower lobe bronchus showed narrowing and infiltration near the point of origin of the right middle lobe bronchus. The main bronchus of the right middle lobe was infiltrated for a distance of 1.0 cm., and a 2-cm. segment of the adjacent right lower lobe bronchus appeared infiltrated. On cross-section (Fig. 5) gray-white tumor tissue was seen surrounding the right lower lobe bronchus, apparently infiltrating toward the capsules of the adjacent nodes.

The surrounding lung parenchyma was free. No pulmonary consolidations or metastases were noted. The histologic examination of sections through hilar and juxta-pericardial nodes failed to reveal metastases. The final diagnosis was bronchogenic carcinoma of the right middle and right lower lobe bronchi.

These 2 cases also illustrate the potential seriousness of cough, expectoration, hemoptysis, and wheezing in the adult beyond

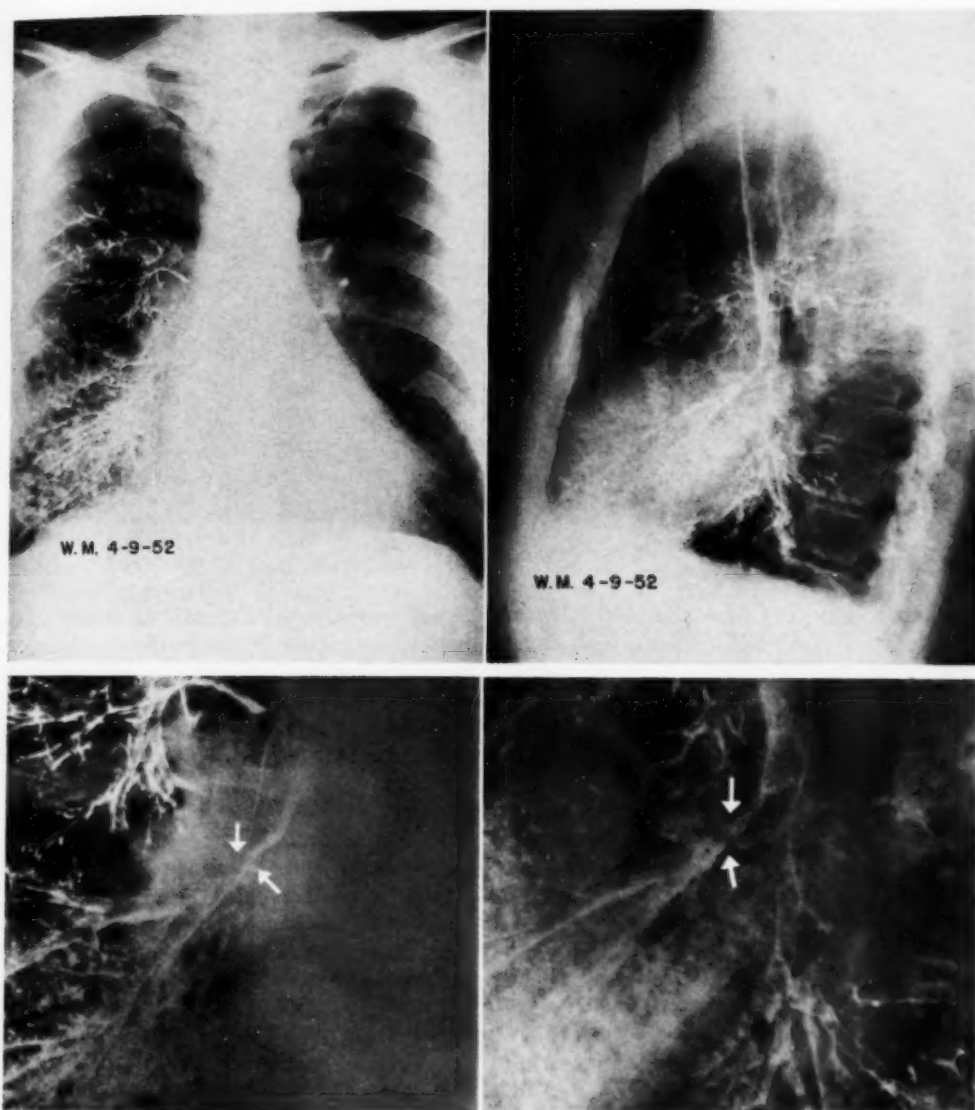


Fig. 4. Case II. Bronchograms showing irregular narrowing of the main bronchus to the right middle lobe and the adjacent right lower lobe bronchus.

forty years of age. These symptoms and the few physical findings were regarded as warranting further investigation, even though in each instance a conventional chest film was interpreted as normal. The investigation took the form of bronchography, bronchoscopy, bronchial cell studies, bronchial biopsy, and exploratory thoracotomy, in rapid succession. Al-

though both patients had normal chest films, only the second had a resectable lesion. In each case there was a lapse of three months between the onset of symptoms and operation. This interval compares favorably with the average of 12.3 months between onset and operation in the group of 332 operated cases reported by Ochsner and his associates (7).

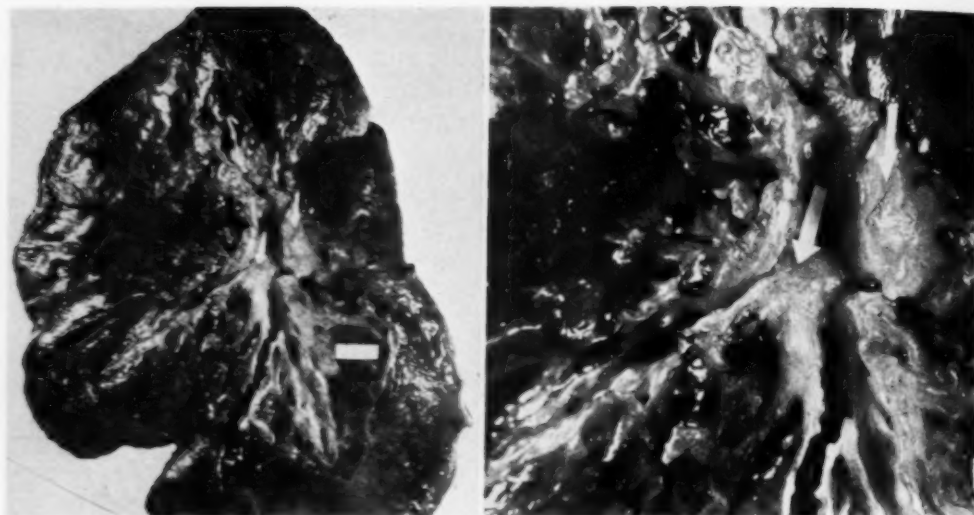


Fig. 5. Case II. Operative specimen.

Bronchogenic carcinoma almost always reveals itself on the conventional chest film. The roentgen signs of this disease are obstructive emphysema, unresolving pneumonia, segmental or lobar atelectasis, lymphangitic infiltrates, tumor nodule, thick-walled abscesses, hilar or mediastinal masses, or pleural effusion.

Bronchogenic carcinoma of the larger bronchi, in contrast to the silent peripheral carcinoma for whose discovery we depend upon survey films, produces the symptoms of cough, expectoration, hemoptysis, and wheezing relatively early. If patients and physicians become increasingly aware of the potential neoplastic significance of these symptoms, we may anticipate that more adults will present themselves for medical examination when their chest films are still normal.

Ochsner and his associates found it unusual for a symptom-producing lesion to be so located as not to be demonstrable on a plain chest film. Only 2 of his group of 332 operated patients had initially normal chest films. In a group of 200 patients with bronchogenic carcinoma, Rabin found 5 normal chest films (11). He states (10): "In early carcinomas of the root of the lung which have not

caused atelectasis, the neoplasm may be completely hidden by the mediastinal structures so that its presence is not revealed by the roentgen film." Overholt (8) and his associates have observed 3 patients with bronchogenic carcinoma and normal chest films. One such case is mentioned by Robbins (13). In that instance the chest film and bronchoscopic findings were both normal, while the bronchial washings were positive for tumor cells. Not until two months later were roentgenography and bronchoscopy positive. Steinberg and Dotter (14) mention 2 cases.

In a paper on limitations of the chest film in diagnosis, Rigler (12) emphasizes the extreme rarity of the normal chest film when the larger bronchi are involved by carcinoma. He suggests that in the case of a normal report there is apt to have been a diagnostic error, such as failure to recognize slight unilateral hilar enlargement, failure to observe minor degrees of obstructive emphysema, disregard of linear atelectasis of a small lung segment, or overlooking small infiltrates obscured by hilar root shadows and vascular trunks.

To minimize the incidence of error, Rigler stresses the importance of a complete radiographic examination, including fluoros-

copy, inspiratory and expiratory films, and multiple views of the chest. One must confess, however, that errors are sometimes unavoidable, since the minimal signs of bronchogenic carcinoma closely resemble unimportant changes occurring in the lungs of persons in the older age groups.

According to Rabin (10) the chest films of older patients often show aged and weather-beaten lungs and hilar roots. Differences of intensity and asymmetry of hilar root shadows, when not the results of constitutional variability, may be due to minor pathological conditions such as old pulmonary or bronchial infections, anthracosis, or old pleural adhesions. Similarly, emphysema and small linear atelectasis are often of benign rather than of malignant origin. Radiologists who do chest surveys in older population groups well know how often slight hilar asymmetry, linear atelectatic shadows, and emphysema occur in the absence of bronchogenic carcinoma. On the other hand, these minimal radiographic findings, when they occur in association with respiratory symptoms, should alert us to the possibility of bronchogenic carcinoma.

The report of a normal chest film in an adult with respiratory symptoms of cough, expectoration, hemoptysis or wheezing should be followed by further investigation with bronchography, bronchoscopy, biopsy, and cell studies of bronchial secretions. A normal chest film cannot be considered an absolute proof of the absence of broncho-

genic carcinoma. Even with an abnormal chest film, a bronchogram may help greatly by indicating bronchial occlusion.

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SUMARIO

La Broncografía en el Diagnóstico del Carcinoma Broncogénico en Dos Enfermos con Radiografías Torácicas Apparentemente Normales

Preséntanse 2 casos de carcinoma broncogénico comprobado en que las radiografías torácicas corrientes no habían revelado la menor anomalía. Ambos enfermos se quejaban de tos, hemoptisis y jadeo, síntomas estos que, unidos a pequeños hallazgos físicos, condujeron a investigaciones ulteriores, comprendiendo broncografía, bron-

coscopia, estudios de las células bronquiales, biopsia y toracotomía exploradora. En ambos casos, los broncogramas revelaron estenosis bronquial y la broncoscopia estableció la existencia de una lesión constrictora, comprobada después con la exploración.

Dedúcese que, cuando existen síntomas

sospechosos, no debe considerarse una radiografía torácica normal como prueba absoluta de la ausencia de cáncer broncogénico, hallándose indicadas nuevas investigaciones en esos casos. La broncografía representa un procedimiento inocuo de consultorio y, aun en los casos que no

plantean problemas radiográficos de diagnóstico, puede resultar útil para localizar el sitio de la oclusión. En el estudio de las afecciones pulmonares oscuras desempeña una misión semejante a la de la serie gastrointestinal, del colecistograma y del pielograma en las afecciones abdominales.



Protection Measures in a University¹

TITUS C. EVANS, Ph.D.

THE PROBLEMS involved in radiation protection in a university differ in some respects from those in a hospital or in an atomic energy installation. In general, the potential hazards are not great but they are extremely varied. In a large university, ionizing radiation may be used in one form or another in practically all fields of science. Likewise, nearly all of the potentially hazardous factors are involved (penetrating radiation, localized exposure, ingestion, inhalation, contamination, biologic concentration, waste disposal) and must be evaluated. An additional problem is that the investigators have different backgrounds in training and experience. They are, in general, responsible and co-operative, but some may have a tendency to neglect their safety in their zeal to obtain new information. Protection measures should be designed to protect the individual, the university, the community, and the state, but at the same time should not hamper unduly the progress of teaching and research. The following remarks are not to be regarded as rules, but only as conclusions of the writer based on his own experience and on his interpretation of correspondence with those with whom he has communicated.²

GENERAL MEASURES COMMONLY USED IN UNIVERSITIES

In agreement with the regulations of the Isotopes Division of the A.E.C. (5, 6) and with the recommendations of the National Committee on Radiation Protection (12), guarding against possible hazards of radioisotopes usually begins at the procurement level. This is done by forming a University (Local) Radioisotopes Com-

mittee. Although the details of procedure vary slightly, the Committee usually requires approval by one or more of its members before any local request for radioisotope allocation may be sent to the A.E.C. or to any other agency. Records are kept of each purchase and of the final disposition of the material. The chief concern of the Committee is that the purchaser, or user, be acquainted with the potential hazards involved and that he have the experience, interest, and equipment necessary to avoid them. In addition to the scientific members of the Committee, there is usually a representative of the administrative offices to help in matters pertaining to the purchasing department, maintenance department, legal aspects, and public relations.

One of the initial activities of the Committee is to draw up a statement of its scope, responsibilities, and plan of action. The first regulations usually have to do with procurement. The next deal with acceptable procedures under various conditions. These regulations become more detailed and are modified from time to time with experience, and as uses become more widespread. One member of the Committee is delegated as the person responsible both to the Committee and to the individual investigators using the radioisotopes. He is known variously as "health physicist," "radiological safety officer," "radiation protection officer," or "chairman of the Radioisotopes Committee" (or chairman of the University Radiation Safety Committee). In large institutions, one man (or more) may devote his entire time to radiation protection problems and his activities may include

¹ From the Department of Radiology and Radiation Research Laboratory, State University of Iowa, Iowa City, Iowa. Presented as a part of a Symposium on Radiation Protection, at the Fortieth Annual Meeting of the Radiological Society of North America, Los Angeles, Calif., Dec. 5-10, 1954.

² The writer wishes to acknowledge that in answer to his request, he has received prompt and informative letters from the following: J. E. Willard, University of Wisconsin; F. E. Hoecker, University of Kansas; R. P. Gosson and J. W. Thomas, University of Pennsylvania, and G. W. Morgan, Radiological Safety Branch, Isotopes Division, U. S. Atomic Energy Commission.

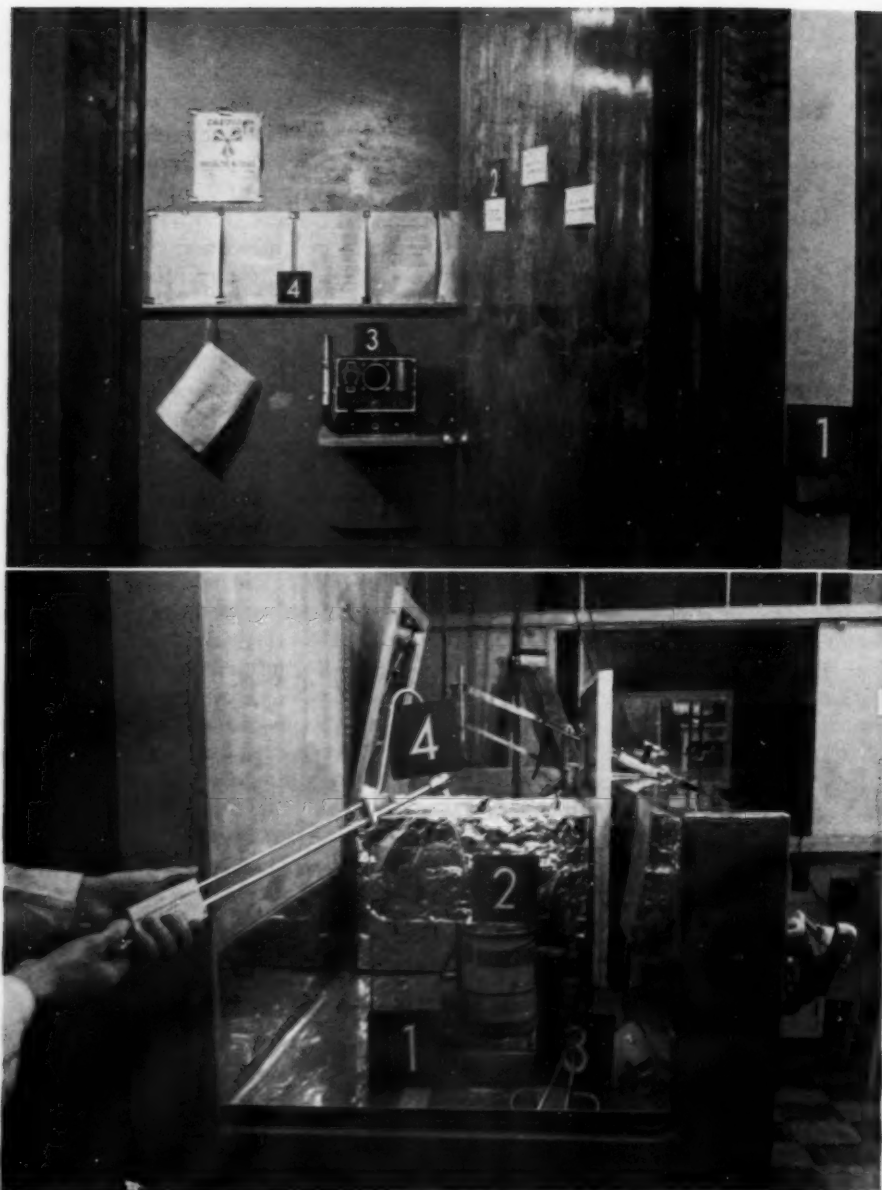


Fig. 1 (above). Although each department in the University may have its own counting equipment for low-level tracer uses, work with moderate and high levels of radioactivity is best done in one central "hot lab." This photograph shows the entrance to such a room and illustrates the following details: (1) ash tray outside of the room; (2) warning signs on door ("radioactivity laboratory," "do not enter without permission," "no smoking, eating, etc., in this room"); (3) aural monitor for checking hands, etc., before leaving area; (4) safety rules and procedures in case of emergency or accident.

Fig. 2 (below). Area for handling of low and moderate levels of radioactivity, showing (1) thick glass shield; (2) radioisotope container; (3) tongs; and (4) remote-control pipette.

routine checking of all facilities where radioisotopes are used.

PROTECTION MEASURES AT A PARTICULAR INSTITUTION

At the State University of Iowa, the Radioisotopes Committee is large (16 members), including representatives from

to safeguard individuals, and the public in general, from possible hazards of work with radioisotopes in the University. It is recognized, however, that the ultimate responsibility for his own safety and for those working with him rests with the individual using the radioisotopes." The Committee is large in order to assure rep-

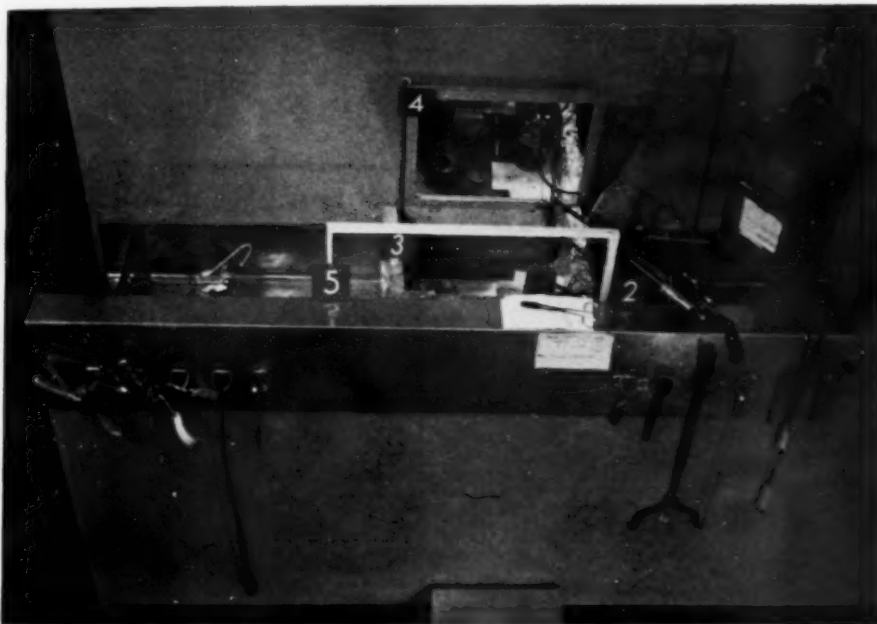


Fig. 3. Equipment for dispensing strongly radioactive solutions. (1) Reflection in mirror of adjustable stand which supports the radioactive material in its shielded container. (2) Remotely controlled pipette. (3) Lead bricks forming wall around working area. (4) Mirror. (5) Thick glass for direct observation. The low-level working area is shown at the extreme left, and the hoist for heavy containers is at the extreme right of the trough, which is of concrete and is lined with stainless steel.

the following areas: (1) Radiation Biology (chairman), (2) Radiology, (3) Medical Physiology, (4) Radiation Biochemistry, (5) Radiation Biophysics, (6) Internal Medicine, (7) Chemistry, (8) Physics, (9) Nuclear Physics, (10) Department of Health, (11) Graduate College, (12) Botany, (13) Zoology, (14) Engineering College, (15) Pharmacy, (16) College of Medicine, with the President's Office and Business Office, *ex officio*. The scope of the committee is outlined as follows: "The University Radioisotopes Committee shall prepare and administer regulations

representation of all areas using radioisotopes and to have advice available from men experienced in the various aspects of physical and life sciences. Since the entire group is too large to consider each application, this is done by the representatives from areas 1, 2, and 3. If one of these is absent from the campus when an application comes up, then the member from area 4 serves, and so on. This permits immediate action at any time. Applications involving uses in man must also have the approval of the clinical members of the Committee (areas 2, 6, and 16).

Safety regulations are suggested by a subcommittee and are approved by the entire University Radioisotopes Committee. The general direction of the safety regulations is under the supervision of the Department of Radiology. The head of the Radiation Research Laboratory (who is also a member of the Department of

include the use of special facilities such as shielded hoods, monitoring equipment, survey instruments, storage, and disposal facilities. All shipments of radioactive isotopes, unless otherwise specified, are delivered to the Radiation Research Laboratory, and unpacking is done under supervision in a special room (see figures



Fig. 4. Shielded hood for chemical work with radioisotopes emitting high-energy radiation. (1) Sliding doors of 1/8-inch lead sandwiched between two sheets of 1/8-inch steel. Top, sides, back, and bottom of the hood are also shielded with 1/8 inch of lead. (2) Holder for information concerning material, procedure, user, etc. (3) Plastic shield. (4) Mirror. (5) Monitoring detector for checking shielding and procedures. (6) Removable stainless steel trays. (7) Remote control for water (similar controls for gas, air, etc., are under the left bench).

Radiology and chairman of the University Radioisotopes Committee) utilizes the services of the staff of this laboratory, which includes a physicist with special training in health physics, a biochemist with considerable experience in the use of radioactive materials, and a biologist with many years of experience in biologic effects of x-rays, neutrons, and of radioisotopes. The Radiation Research Laboratory acts as the agency of the University Radioisotopes Committee in assisting the investigator in carrying out provisions of the safety regulations. These

for further detail concerning these facilities).

In addition to the usual safeguards such as shielding, mechanical pipetting, proper labeling, and records, the user is required to wear a film badge and pocket dosimeter unless he is specifically exempted by the protection officer. Each department using radioisotopes must designate one individual responsible for seeing that the safety regulations in that department are carried out. Violations or accidents are to be reported immediately to the Radiation Research Laboratory for correction.

Where disciplinary action is required, the University Radioisotopes Committee will report to the office of the president of the university for action. A detailed set of regulations for use of all radioisotopes has been prepared and copies are supplied to each department. A more recent outline for use of carbon-14 specifically has also

low to penetrate the film badge. It has been decided, however, to make exceptions only in very special instances, as most of these workers will from time to time be in areas where they are exposed to penetrating radiations. In addition, this assures a weekly visit to each user by a member of the Radiation Research Lab-



Fig. 5. Disposal and clean-up area. (1) Sink with hot and cold water. (2) Stable phosphorus and iodine solutions used in reducing specific activity of radioactive wastes of these elements. Various cleaning agents are also available here. (3) Work area for cleaning contaminated equipment. (4) Combination "hot" sink and washing unit. (5) Disposal container for contaminated paper, etc. (6) Container for larger disposable items. An "inter-communication" unit at the upper right is convenient for messages to and from the outside.

been prepared and distributed. These regulations are intended to coincide, for local application, with the general suggestions of the Isotopes Division of the A.E.C. and of the National Committee on Radiation Protection.

Two regulations, which have aroused considerable discussion, have been allowed to stand because of the importance of records and because, if they err at all, it is in being too conservative. The first of these is that all radioisotope users wear film badges. Some of the users, it is true, work with radiations of energy too

oratory staff. This weekly exchange of an old for a new badge serves to remind the user that he is working with material of potential danger whether it be an external or an internal one. The second regulation is the requirement of a physical examination (including blood studies) of each applicant before he uses radioisotopes. It is the conclusion of the Committee that each potential user owes it to himself and to the university to be aware of any physical abnormality before he engages in research with radioisotopes. Any unusual condition that might be con-

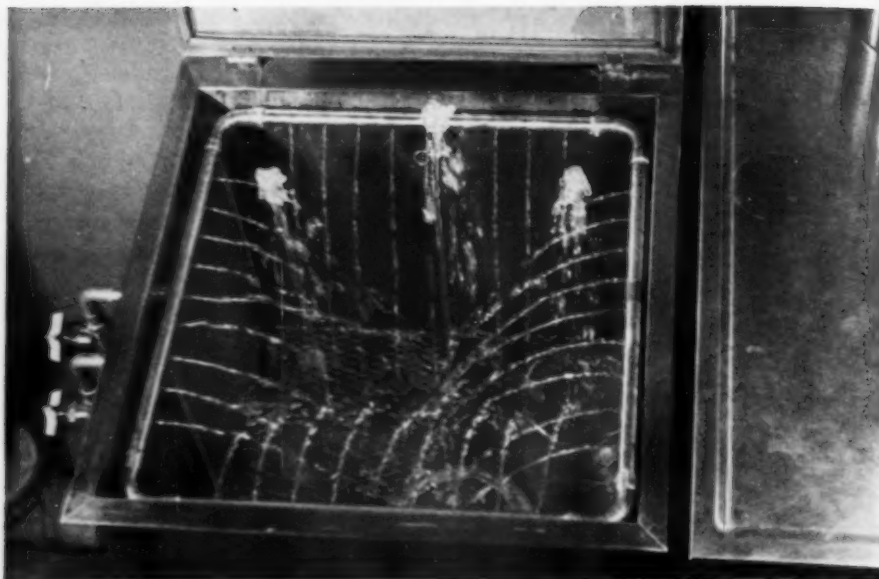


Fig. 6. Detail of sink and washing unit. There are eight jets of water from below and a ring of smaller jets at the top. The force of the water above and below the glassware is controlled by the two valves at the left.



Fig. 7. A view of one side of the storage area. (1) A door (1/4 inch lead between two 1/8 inch sheets of steel) of one of the double-height compartments. (2) A single-height compartment door. (3) Heavy container on hoist which transports such material to "hot" laboratory immediately above. (4) Refrigerator for storage of solutions that might deteriorate at room temperatures.

fused with radiation-induced changes may contraindicate use of radioisotopes by a given individual. The frequency and extent of further examinations are set by the Department of Radiology and are governed by the estimate of the particular potential hazard involved.

These regulations have been in use at this institution for six years and no major difficulties have been encountered. Tact and understanding have been employed by both protection officers and investigators. The importance of preventing even minor accidents is realized by everyone concerned. It is assumed that, for the present, any unfavorable publicity would be much more serious than that resulting from better understood accidents as, for example, those involving fire and poisons.

In many instances, the potential hazards are reduced by techniques already required by the experimental procedures. For example, if a radioactive material of long half-life is used, it is important from a technical standpoint, as well as from the protection aspect, that extreme methods of good housekeeping and contamination-prevention be employed. In tracer work, only very small quantities need to be taken into working areas. The chief problem encountered so far has been that of disposal of radioactive wastes, especially when left behind by an investigator who has departed from the campus. Some of these may not be adequately labeled, and it must be assumed that they represent potential hazards. So far, the ultimate solution has been postponed, since adequate storage facilities are still available.

In addition to radioisotopes, most universities have a number of particle accelerators or other sources of ionizing radiation. These usually are x-ray machines and high-energy accelerators of the types used in nuclear physics studies. In this institution, the Radiology Department has been responsible for protection measures for all machines in the hospital and

College of Medicine. This responsibility has been broadened to cover the entire campus, and the Radiation Research Laboratory has acted as its agent in working with investigators to insure use of proper protection procedures. Even in the clinical areas, workers comply with regulations of the University Radioisotope Committee, but in this instance the Department of Radiology is usually consulted directly.

In summary, radiation safeguards in a university would appear to be maintained most successfully by rigorous training and self-discipline, by a willingness on the part of the users to be extremely cautious in preventing those conditions which might give rise to either adverse publicity or mental unrest even though permissible exposure levels are not exceeded. Supervision may be carried out by routine visits by a radiation protection officer to each user's laboratory, by providing a central "hot lab," where potentially hazardous materials are handled in collaboration with members of that laboratory, or by a combination of the two methods.

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SUMARIO

Las Medidas de Protección contra la Radiación en una Universidad

Ilústranse aquí las medidas de protección contra la radiación utilizadas en una universidad con una reseña de los procedimientos emprendidos en la Universidad del Estado de Iowa.

Una Comisión de Radioisótopos, compuesta de representantes de los 16 departamentos de la Universidad que usan esos cuerpos, vigila y registra el empleo de substancias radioactivas en el establecimiento en cada una de sus etapas, comprendiendo obtención, uso en el laboratorio y disposición final. Se hacen esfuerzos para familiarizar a los que usan dichas substancias con sus riesgos potenciales y para iniciar procedimientos aceptables para el empleo de radioisótopos en varias circunstancias. Los reglamentos de seguridad y las salvaguardias comprenden resguardos, rotulado adecuado de las substancias y mantenimiento de protocolos; se requiere que los sujetos que van a usar el material pasen un examen

físico antes de ponerse a trabajar con radioisótopos, con mira al posible descubrimiento de alguna anomalía física. A los dedicados a este trabajo se les exigen películas registradoras y dosímetros de bolsillo. Cada departamento que usa radioisótopos designa a una persona para que haga cumplir los reglamentos de seguridad. Las infracciones y los accidentes se denuncian en el acto; las situaciones que exigen providencias disciplinarias se llevan al conocimiento de la Oficina del Presidente de la Universidad.

Opina el A. que, con los procedimientos bosquejados, se mantienen las salvaguardias contra la radiación en una Universidad. Sugiere que cabe llevar a cabo la vigilancia por medio de visitas periódicas verificadas por un funcionario de protección contra la radiación, estableciendo un "laboratorio térmico" central en el que se manipulen las substancias potencialmente peligrosas, o por medio de los dos métodos.

DISCUSSION

Robert O. Gorson, M.S. (Philadelphia, Penna.): Dr. Evans has covered a number of important points that any institution must consider in order to set up a realistic, workable, and harmonious radiation protection program. I should like to emphasize a few of these points and to indicate a slight modification in approach to the problem that we at the University of Pennsylvania have found advisable under the conditions that exist in our particular institution.

The first point is the scope of the Committee. Recently we have changed the title of our committee from the University Isotope Committee to the University Radiation Safety Committee, and we have extended the scope to include the control of radiation hazards from all sources of ionizing radiations, whether they are radioactive materials

supplied by the A.E.C., natural radioactive elements, or x-ray machines and other particle accelerators. The potential radiation hazards that exist arise to a large extent from non-A.E.C. supplied radiation sources. Besides being concerned about the over-all radiation protection problem as it exists at the University of Pennsylvania, we feel that we can more effectively satisfy and live up to the recommendations and requirements of the A.E.C. by officially including within the scope of the committee some control over radiation hazards arising from sources of ionizing radiation which are not under the jurisdiction of the A.E.C.

The chief concern of the Radiation Safety Committee, as Dr. Evans indicated, is that personnel employing or working with sources of radiation be

aware of the potential hazards, that they have the knowledge and experience to evaluate these hazards properly, and that they have adequate facilities and equipment to control and minimize the hazards. A secondary concern that we feel falls logically under the jurisdiction of such a committee is some assurance that any proposed project is experimentally feasible, especially in respect to medical use, and that the project will not interfere with some other research program so far as the use of the radiation source is concerned.

The Radiation Safety Committee of the University of Pennsylvania does not make it a blanket requirement that all users of radiation sources wear monitoring devices such as film badges or pocket chambers. Any such requirement is left to the judgment of the Radiation Safety Physicist, who is guided by certain general rules established by the Committee and can refer any case of doubt or dispute to the Committee for final decision. This arrangement has been agreed upon partly because of the inherent limitations on the accuracy of the usual film badge dosimetry technic under varying conditions of exposure to different kinds of ionizing radiation. We have found it advisable to spend perhaps a greater fraction of the available funds on radiation monitors for area surveys rather than for direct personnel monitoring. We feel that the emphasis

should be placed on education in the proper use of these area survey instruments. In some cases the use of personnel monitoring devices may have a good psychological effect in promoting safe practices, but in other cases negative readings from film badges can promote a false sense of security.

The Committee's requirements as to the frequency of blood counts is also flexible, depending upon individual circumstances. We make a strong point of emphasizing that blood counts are not to be considered as a monitoring procedure. Like Dr. Evans, we prefer to examine blood counts for any contraindication to occupational exposure to ionizing radiations, rather than as an index of the degree of past exposure.

The last point I should like to emphasize is the designation of some one person in each project or department to be responsible to the University Radiation Physicist for the local radiation protection problem. Unless this responsibility is clearly delegated, the Radiation Safety Physicist may find himself in the position of having direct responsibility for radiation safety in a project with which he has little direct contact. We feel that the Radiation Safety Physicist can work more effectively in an advisory capacity and as the liaison officer between the University Committee and the individual radiation users.



Cobalt 60 Protection Design¹

C. B. BRAESTRUP and R. T. MOONEY

THE RECENT REPORT by the National Committee on Radiation Protection, published as *Bureau of Standards Handbook 54* (1) includes basic information on cobalt 60 teletherapy shielding. So far as experimental attenuation data for the primary and 90° scattered radiation are concerned, the *Handbook* is particularly complete; data based on experience with completed installations, however, are limited, since cobalt teletherapy is a rather recent development. It is the purpose of the present report to give this supplementary information. The study includes surveys of completed installations, the design of which was based on experimental attenuation measurements (2-4).

In Figure 1 are shown schematically the three types of radiation which should be considered in protection design; the useful beam, scattered radiation, and leakage radiation. Since the intensity and energy of the scattered radiation vary with angle of scatter, size of field, etc., its attenuation presents the more difficult problem.

The structural shielding requirements of teletherapy installations vary widely and depend on a number of factors, the most important of which are as follows:

1. Degree of occupancy of nearby regions.
2. Orientation of useful beam.
3. Type of equipment.
4. Weekly work load in r/week at 1 meter (in air).

1. *Degree of Occupancy:* *Handbook 54* is the first protection code to give occupancy factors for areas of various types. This permits the designer to adjust the barrier thickness to meet actual requirements. A stairway, for instance, is assumed to be occupied not more than one-sixteenth of the time by the same personnel. Since

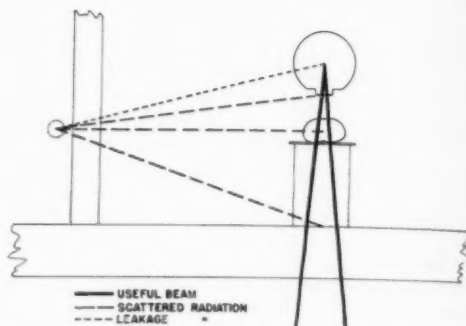


Fig. 1. Schematic diagram showing the three types of radiation which should be considered in room protection design.

an occupancy factor of 1/16 reduces the required thickness by four half-value layers, a primary concrete barrier is reduced by 10 inches. It is obvious, therefore, that significant savings can be gained by proper location of the teletherapy room with respect to occupancy of surrounding regions and by orientation of the equipment so that the beam is directed toward an outside wall. Where there is a possibility of a future increase in the degree of occupancy, it is more economical to provide for this originally. A corner room on the bottom floor, preferably below ground, usually requires minimum shielding. This does not necessarily mean minimum expense, since excavation may cost more than the required additional shielding.

In some instances, it is more practical to locate the telecobalt room on an upper floor in order that it be close to existing x-ray therapy facilities. In such cases efficient shielding design is essential. This is not merely a matter of cost. Often the weight of the shielding determines whether an upper-floor location is feasible.

2. *Orientation of Useful Beam:* The most effective way of reducing the shielding

¹ From the Physics Laboratory, Francis Delafield Hospital, New York, N. Y. Presented as part of a Symposium on Radiation Protection, at the Fortieth Annual Meeting of the Radiological Society of North America, Los Angeles, Calif., Dec. 5-10, 1954.

cost and weight is by limiting orientation of the useful beam to actual requirements. Such restriction permits the use of secondary barriers of less thickness for all areas exposed only to scattered and leakage radiation. Obviously, the beam should preferably be directed toward areas where the occupancy factor is low.

3. *Type of Equipment:* The leakage radiation depends on the type of beam control used, as shown in Figure 2. Where shutters are used, the leakage radiation is almost the same in the "on" and "off" positions. The leakage radiation must be low in the "off" position to permit personnel to enter the telecobalt room between treatments. According to *Handbook 54*, the leakage radiation in the "off" position should average not more than 2 mr/hr. at a source distance of 1.0 meter. With shutter type of equipment meeting this requirement, the leakage radiation may therefore be ignored in determining the structural shielding requirements, since 2 mr/hr. is insignificant compared with the much higher dose rate of the scattered radiation.

If the beam control is accomplished by moving the source, the leakage radiation is usually considerably higher. In fact, it may be several thousand times greater and still comply with the regulations of *Handbook 54*, which allows a leakage radiation in the "on" position of 1 per cent of the useful beam. For a kilocurie source this corresponds to about 12,000 mr/hr. at 1.0 meter.

Actually, most commercially available source housings have a leakage radiation of less than 1 per cent in the "on" position. It would be of advantage if the manufacturers would agree on a maximum figure of 0.1 per cent. Until such standardization has been achieved, it is essential to obtain complete information on the leakage radiation of the source housing before determining the room protection.

Installations with equipment provided with a built-in primary shield require significantly less room protection. Since, however, such a shield usually covers

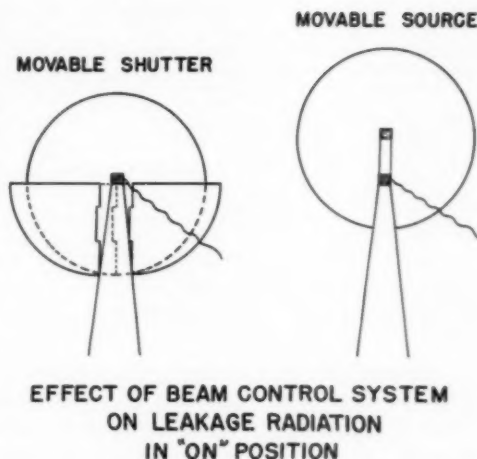


Fig. 2. Teletherapy equipment utilizing movable shutters for beam control will have approximately the same leakage radiation for both the "on" and "off" position. When beam control is accomplished by moving the source, the leakage radiation in the "on" position is usually considerably higher than in the "off" position.

only a relatively small solid angle, protection must be provided against radiation scattered through angles of only 30 to 40°. Obviously, the published tables for 90° scatter cannot be used for this purpose.

The thickness of the shield should preferably be such that the transmitted radiation is of the same order as the sum of the scattered and leakage radiation in the "on" position. Further attenuation of the primary beam will result only in a minor reduction (less than one half-value layer) in room shielding.

4. *Weekly Work Load:* This factor depends on the curiage of the source and cumulative weekly treatment time. It should be realized, however, that the work load is not necessarily proportional to the curiage, since the time between treatments is not affected by the source strength. This is illustrated in Table I, which shows that tripling the curiage may only double the work load. The required increase in shielding thickness is, therefore, only one half-value layer or 2 1/2 in. for primary concrete barriers. Since these usually are several feet thick,

TABLE I: RELATION BETWEEN CURIAGE AND WORK LOAD

Curies (r/min. at 1.0 meter)	Minutes per Treatment	Weekly Work Load
600 approx. (10)	Exposure 15	18,000 r
	Set-up 5	
	20	
1,800 approx. (30)	Exposure 5	36,000 r
	Set-up 5	
	10	
Tumor dose per treatment	200 r	
Weekly working time	40 hours	

an increase of a few inches adds relatively little to the cost. In new construction where weight is no restriction, it is advisable to design the shielding for the maximum possible future work load.

ROOM SHIELDING DESIGN

The thickness of primary barriers may be determined directly from the tables of *Handbook 54*. These, based on measurements by Kennedy, Wyckoff, and Snyder (3), provide a high factor of safety for teletherapy conditions.

The determination of secondary barriers requires more extensive computation. *Handbook 54* contains data for 90° scatter only. The report by Dixon, Garrett, and Morrison (2) includes valuable information for smaller angles. Unfortunately, the factors determining the secondary shielding requirement of teletherapy installations may differ considerably from laboratory conditions. Until more experimental data are available, the relation between the shielding and stray radiation of completed telecobalt installations provides a valuable guide in shielding design.

PROTECTION SURVEYS

Protection surveys were made on four telecobalt installations designed in accordance with our shielding specifications. A preliminary scanning was made at each installation with Geiger counters to determine the locations of maximum radiation. Because of the variation in sensitivity of the counter with direction and with radiation quality, this instrument was not used for quantitative measure-

ments. These measurements were made, instead, with large condenser ionization chambers previously described (5). All measuring instruments used were calibrated with gamma rays from a known source of cobalt 60.

Figures 3 and 4 show two views of a kilocurie installation located on the third floor of a clinic building. The beam orientation was limited to a vertical plane. It was necessary to keep the shielding weight and space requirements to a minimum, since no provision was made for cobalt in the original building plans. This accounts for the liberal use of lead.

It may be of interest to compare the calculated and measured stray radiation. The concrete lead shielding of the floor was designed to reduce the useful beam to 5.8 mr/hr. in the utility room below, which is only partially occupied. This is almost five times the measured values. Part of this difference may be ascribed to attenuation by the structural steel; however, even the part of the useful beam which passes between the steel is almost as low. It appears, therefore, that there is in effect "narrow beam" attenuation. Compared with concrete, the steel absorbs the softer scattered radiation more effectively.

The calculated and measured values of the 90° scattered radiation agreed closely—for the control space 1.2 against 1.1 mr/hr. A recent report by Jacobson and Knauer (6) indicates that leakage radiation from a similar unit is insignificant compared with the scattered radiation. As might be expected, the lead is very effective for the ceiling, which is exposed to radiation scattered at least 90°.

During clinical use of the equipment, the unattenuated beam is not pointed at the street. However, by raising the source housing to maximum height, it is possible to direct the beam toward the steps of a cathedral several hundred feet away. Measurements at 400 feet gave a dose rate of 40 per cent of that calculated from the inverse-square law. It was found also that the apparent absorption coefficient of

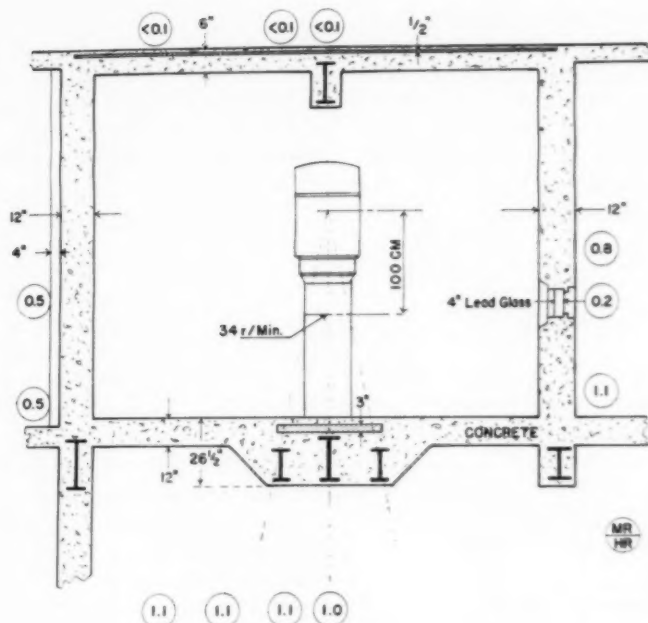


Fig. 3. Front elevation of a kilocurie installation. The shaded area indicates lead.

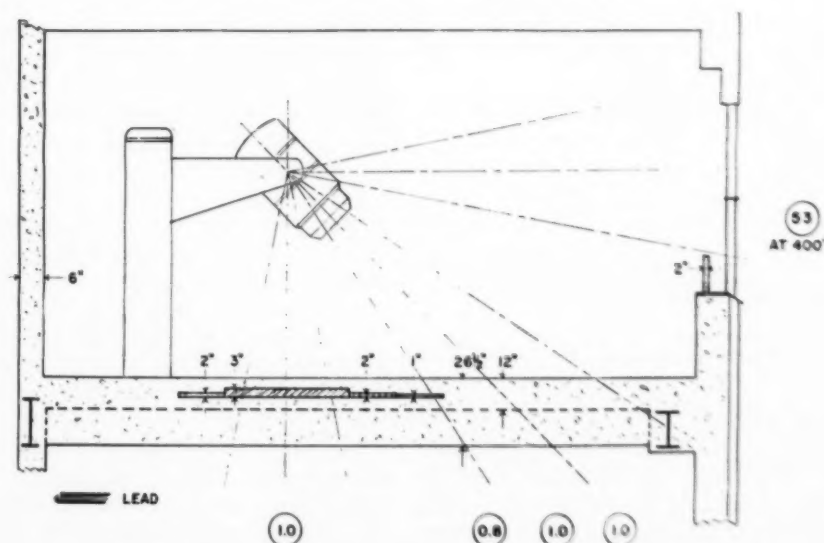


Fig. 4. Side elevation of kilocurie installation. The encircled figures indicate mr/hr. for the three beam orientations shown.

air increased with distance. This might be expected as a result of the Compton effect, although scatter from nearby buildings might mask the results. In order to

reduce the unattenuated beam to a level of 7.5 mr/hr., permitting forty hours irradiation per week, a distance of about 700 feet would be necessary.

greater. Without the built-in primary shield, the walls exposed to the useful beam would have had to be 5 ft. of brick, or 3 ft. 4 in. of concrete, to give the same attenuation. The door is so located that it is exposed only to radiation which has been scattered at least twice. As a result, 3 mm. lead provides adequate protection.

that radiation is reduced to the permissible level for the worst operating conditions, the average weekly dose generally is considerably below the maximum permissible. Personnel monitoring for installations so designed indicates that the weekly exposure of technicians averages considerably less than 30 mr for usual treatment

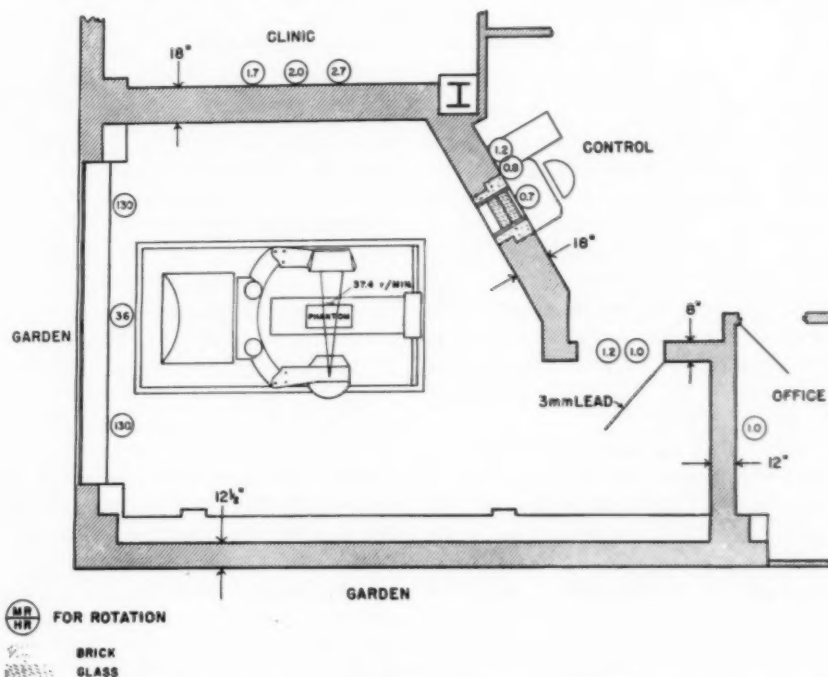


Fig. 8. Kilocurie installation designed specifically for rotating teletherapy. The high dose rate at the outside window has since been reduced by means of a lead barrier attached to the equipment.

FACTOR OF SAFETY

The required factor of safety in shielding design, unfortunately, is a rather controversial subject. Some consider it perfectly justifiable to design protection so that persons, week after week, receive the maximum permissible dose; others believe that any radiation much above background should be avoided. Between the two extremes is a factor of about 100, corresponding to almost seven half-value layers of shielding. For the primary beam this amounts to about 17 in. of concrete.

Since protection has to be so designed

conditions. It appears, therefore, that no other factor of safety needs to be included. If one-tenth of the maximum permissible dose is not considered safe, it is time to reduce the maximum permissible dose.

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SUMARIO

Plan de Protección contra el Cobalto-60

El creciente empleo del Cobalto-60 para la teleterapia ha ampliado la necesidad de contar con información más completa para determinar los requisitos de resguardo estructural. El informe de la subcomisión de la Comisión Nacional de Protección contra la Radiación contiene datos adecuados para la atenuación útil del haz. En cambio, no es completa la información ofrecida en cuanto al resguardo contra la radiación secundaria. A consecuencia de ello, a menudo se ha facilitado resguardo inadecuado o excesivo.

Este trabajo es un informe relativo a los resultados de una investigación de la atenuación de la radiación dispersa en situaciones que se suelen encontrar en las instalaciones de teleterapia con Cobalto-60. La atenuación de la radiación dispersa en

plomo y en materiales de construcción se determinó como función del ángulo de dispersión, del tamaño del campo y de la clase de colimación.

A base de este estudio, se calculan los requisitos de resguardo para varios planes de construcción. Se hicieron estudios de la protección en instalaciones ya completas, comparándose los resultados con los valores calculados. Como hay que proyectar la protección de modo que se reduzca la radiación al nivel tolerable en las peores condiciones de funcionamiento, la dosis semanal media es en general considerablemente inferior al máximo tolerable. La vigilancia de las instalaciones dispuestas de esa manera indica que la exposición semanal de los técnicos promedia mucho menos de 30 mr habitualmente.

DISCUSSION

W. K. Sinclair, Ph.D. (Houston, Texas): I have enjoyed listening to this very competent review of a timely subject by Mr. Braestrup, who has had a long experience in dealing with these problems. Many of those who have had the responsibility of designing cobalt-60 teletherapy rooms in the past would have welcomed this information. In fact, I believe many of us would have been saved a good deal of expense. In Houston, for instance, we have a 12-inch lead-glass viewing window. It is quite evident from the work that Dr. Braestrup has done that 4 inches would have been adequate. Since it seems certain, however, that many more of these teletherapy installations are going to be planned in the near future, the report that has been presented is most welcome.

I would like to emphasize, as Mr. Braestrup has already done, that this paper is to be regarded as a supplement to *Handbook 54*, which I have only recently had the opportunity of reading. In particular, I would like to refer to the matter of "occupancy

factors." Although it is a very reasonable concept, and although I think the factors proposed in the *Handbook* are extremely conservative, I cannot say that I welcome their appearance. I would like to point out that the recommendations of protection committees in the past regarding the use of x-ray therapy beams have resulted in practically negligible hazards to technicians operating the machines. Despite the justice of Mr. Braestrup's closing remark about the maximum permissible level, it seems to me that loopholes may be opened up for less careful designers to provide reduced barrier thicknesses, a loophole that I feel can be checked up on with great difficulty. If this is the case, the record of radiation exposures from cobalt-60 units in the next decade may be much less satisfactory than those of the last decade relative to x-ray machines.

I would also like to make a distinction between converting old buildings for the use of cobalt teletherapy and the building of new installations. Converting old buildings is usually a much more expen-

sive process, and if economic factors must be taken into consideration, as they inevitably must, it may be possible to tolerate a minimum of protection in a converted installation. In the case of new buildings, it doesn't cost a lot more to add extra shielding, and the practice of providing what may seem like more than adequate protection should be encouraged. I believe that in the long run this would pay off economically, since changing conditions, such as the orientation of the beam, the strength of the source,

and the occupation of surrounding areas, might not then require a great additional expenditure.

There is one final remark which has little to do with the paper. It concerns the word "curiage." I don't see that we gain very much from using a term like this over the more simple expression, "strength of source." "Curiage" is an ugly word and I am sorry to see its introduction in *Handbook 54* and to observe that it seems to be gaining currency elsewhere.

DISCUSSION

H. M. Parker: Radiation Protection in the Atomic Energy Industry (pages 903-911)

Robert S. Stone, M.D. (San Francisco, Calif.): I suppose you all know that Mr. Parker has been associated with protection against radiations from chain-reacting piles and their products since 1942, when the first chain-reacting pile started to operate in Chicago. He has grown up with this special field through the Metallurgical (Plutonium) Laboratory in Chicago, the first pilot plant of the Clinton Laboratories at Oak Ridge, and the production piles at Hanford. He should and does know more about it than any of the rest of us. Before 1942 he had to deal with protection against x-rays and the beta and gamma rays of radium.

The development of which he spoke, *i.e.*, from a medical to a physical problem, was, I think, very natural. He showed first that in a radiological department, where the main source of radiation hazards occurred in the beginning, the physician in charge of the department was logically responsible for the working conditions of the department, not because he was a physician necessarily or because he was a radiologist, but because he was the administrative head of the department. A lot of us were mistaken in our earlier concepts because the radiologist, a physician, was the administrative head of the hospital department. It rapidly became apparent that the control of physical hazards was something that a physicist should take care of. The physician must have the responsibility of determining the effects of the radiations on people and of determining

those levels that might be classed as permissible. Once this is done, it becomes the physicist's job to see how those hazards can be detected and how they can be controlled. The engineers came into the problem later, when it was necessary for them to build into industrial plants the protection established as necessary by the physicists.

The big problem brought up by Mr. Parker concerns how we are going to provide an expanding field for the people that come in at the bottom of the protection field and want to have somewhere to go at the top. This is not peculiar to men in radiation protection. A person starts in as a mail clerk in a bank and ends up the president of the bank. How he gets there, I don't know. A lot of people stay as mail clerks, and only a few get to be presidents. I think the same thing will happen in this field. Those who have the spark to develop new things will get into the field of research, and those that have the knack for development will go on up in the industrial plants. In the meantime, of course, we have the problem of supply of men. I think the scheme Mr. Parker has worked out at Hanford of being able to take in new people and train them right in the plant is a very worthwhile idea.

One other comment I would like to make. It was mentioned that common sense was the basis of this field. I think that the basis of real common sense is knowledge of the subject with which you are dealing.



Radiation Hazard Evaluation and Control in Hospitals¹

G. FERLAZZO, B.S.,² T. NICHOLSON, A. JACOBSON, B.S., and M. BUSHMAN

NEW TERMS DO NOT necessarily identify new things. Thus, "health physics," "health instruments section," "hazards evaluation," etc., are mostly code terms introduced during the Second World War for identifying, as well as concealing, endeavors which had long been known under the generic title of "radiation protection" or "radiological protection."

Irrespective of terms and titles, the principles and practice of radiation hazard evaluation and control have evolved over the last six decades, concurrently with advances in the technology of x-rays and radioactivity. For the most part, the people responsible for these developments have been radiologists, medical physicists, biologists, and radiation physicists associated with hospitals, universities, and national laboratories such as our National Bureau of Standards.

Unfortunately, the term "health physics," although unrecognized by both our National Committee on Radiation Protection and the International Commission on Radiological Protection, has outlived its wartime usefulness, and has spread so far outside its possibly endemic climate as to create confusion and misconception even in the very fields of radiology and radiological physics. For example, there is a growing tendency, especially among the younger workers, to identify all radiation protective endeavors, hospitals' included, with "health physics" and man-produced radioactive isotopes, as if nothing in the field had existed before the introduction of this term and these isotopes. We are convinced that this trend of thought is contrary to fact. We have found nothing essentially new in our own hospital experience consequent

to the introduction of either man-produced radioactive isotopes or the betatron. Therefore, some clarifying efforts seem to be in order.

We propose (1) to outline the scope of radiological protection as determined by hospital requirements, and to discuss the personality of the medical physicist; (2) to present data pertinent to the location and degree of radiation hazards that may be encountered in hospitals employing both "old" and "new" methods of radiation diagnosis, therapy, and research; (3) to furnish data on the cost of radiation evaluation and control; (4) to summarize these requirements and interpret these data with reference to the trend of thought just mentioned.

SCOPE OF RADIOLOGICAL PROTECTION AND THE MEDICAL PHYSICIST

The scope of radiological protection encompasses all practicable, convenient, and economical procedures for rendering the medical applications of ionizing radiations reasonably safe for all concerned—patients, personnel, and the public at large. The circumstances under which this work must be carried out are markedly variable and often delicate. Decisions, therefore, must frequently be based on considerations of the particular case. In other words, an enlightened expediency is at times required. It would thus seem that the inseparable requisites for the worker in this field include adequate related technical knowledge and a sense of responsibility, experience, and ability to dovetail, conveniently and smoothly, technical knowledge with hospital functions and life.

Accordingly, the introduction of new

¹ From Memorial Center, New York, N. Y. Presented as part of a Symposium on Radiation Protection, by G. Ferlazzo, at the Fortieth Annual Meeting of the Radiological Society of North America, Los Angeles, Calif., Dec. 5-10, 1954.

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sources of radiation, whether radioactive materials or apparatus, would not alter essentially either the scope of radiological protection or the requisites for its worker. On the one hand, any innovation would require some familiarization with the new tool; on the other hand, and to the degree that the new source might affect more hospital personnel and functions than heretofore, the need for intimacy with hospital life would become proportionately greater.

Obviously, then, in order to succeed in his task, the medical physicist must know hospital functions and life; he must have grown in the hospital climate, and have become a part of it; he must appreciate the thinking and problems of patients, physicians, nurses, hospital administrators, and other hospital personnel, at least in so far as these problems affect or may be affected by his decisions and his actions. Also, the medical physicist should always remember that, although he may know how to solve dosage problems on paper, he does not treat patients. By the same token, although he may know how to solve radiation protective problems, he uses discretion and judgment to accomplish economically the best possible results under the circumstances, without at the same time interfering with the care of the patient or otherwise adversely affecting hospital functions or the morale of personnel. In this respect, his job is somewhat difficult; he must see without looking, hear without listening, foresee without presuming, and succeed without ado.

All in all, the medical physicist must be patient and humble, especially when he is out of his laboratory (if he has one); he must realize that his functions are of a supporting or ancillary nature, not directly connected with the treatment and care of the patient.

Some individuals, irrespective of training and titles, are hardly suited to the practice of radiological protection. In general, these are persons with poor manual dexterity, coordination, and sense of housekeeping; they are impractical and unable

to inspire confidence, either too fearful or too careless, and unsympathetic or unappreciative of the problems and feelings of others. On the other hand, there are persons who are quite suited to this work, though they may seem to be a small minority. It is therefore important to select and maintain the proper personnel, not only because of their relative scarcity, but because of the investment involved in training them.

If this analysis is correct, it follows that the practice of medical physics—of which radiological protection is a branch—cannot be learned in any place other than a hospital, assuming, of course, adequate preparation and aptitudes.

LIKELY LOCATIONS AND DEGREE OF RADIATION HAZARDS IN HOSPITALS

About the middle of 1947, L. D. Marinelli,³ head of the Department of Physics at Memorial Hospital at the time, came to the conclusion that efforts should be made to extend protective measures against radiation hazards to all hospital personnel potentially exposed to ionizing radiations; also that these measures should be strengthened within our own department. This conclusion was based on the following observations:

(a) The increasing use and variety of radioactive isotopes in the Hospital was accompanied by an increase in both the number and turnover of inexperienced personnel, with consequent possibility of undue exposure and costly practice.

(b) There were instances of radium and radon appliances and x-ray apparatus being improperly handled, probably due to the influx and turnover of inexperienced personnel.

(c) There were instances of personnel resigning because of unjustified fear of radiation, probably as a reaction to publicity concerning nuclear weapons.

While it was relatively easy to evaluate and control conditions within our own department, it proved somewhat more

³ Associate Director of the Radiological Physics Division, Argonne National Laboratory, Lemont, Ill.

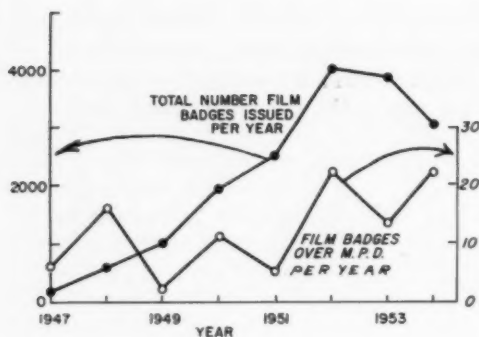


Figure 1

difficult, at first, to extend our methods of evaluation to other departments. Our diplomatic effort to obtain representative data was, however, soon supported by some administrators and heads of departments, though not by all concerned.

At the outset we clearly stated that:

(1) Radiation protective measures were not new at Memorial Hospital.

(2) We wished to obtain additional valid data throughout the Hospital in order to suggest corrections if needed.

(3) With proper precautions, the medical and laboratory applications of radioactive materials, x-rays, and other sources of radiation would present minimal and easily controllable hazards.

(4) For the obvious reason that protection against ionizing radiations—or any other hazard for that matter—remains closely related to the planning and control of operations, and to the hiring and supervision of personnel, the final responsibility for protection always rests with the individual worker and his immediate supervisor rather than with the Department of Physics.

(5) The Department of Physics could only offer guidance and assistance by (a) making the necessary recommendations related to any potential or actual radiation hazard; (b) analyzing radiation protective problems that should precede any contemplated new use of sources of radiation, and/or any change of already standardized techniques; (c) designing or procuring the necessary instruments or tools for

safely conducting operations involving radiation hazards; (d) monitoring personnel, surveying areas, and conducting operation analyses; (e) storing and disposing of contaminated wastes, carcasses, etc.; (f) assisting in any emergency.

Having outlined our program and placed responsibility where it properly belongs, we set out to gain the confidence and enlist the co-operation of all concerned, knowing full well the futility of alternative approaches. Reliance exclusively on rules and regulations had already been tried, with waste of paper and effort as the only evident result. Moreover, the lightly and often proposed idea of police-type measures was hideous to us, and otherwise considered impracticable.

The results of this survey,⁴ as they relate to external radiation, can best be shown by the accompanying illustrations:

1. Figure 1 shows the increase in the number of film badges employed during the period 1947–54, and the corresponding total number that showed readings in excess of the maximum permissible dose (1,200 mr on a monthly basis). Most of the film badges employed were of the Oak Ridge type, and the film packets were changed every four weeks.

In the beginning, we had to plead to have personnel outside our own department wear film badges; but for the last four years we have been pleading against their indiscriminate use. Frequently they serve no purpose other than acting as ornaments, or possibly morale boosters. We cannot, of course, deny badges properly requested by any head of a department or his delegates. Only when we are certain that the requested badges will not serve any useful purpose can we refuse them, and even then it may be unwise to antagonize a department head and appear in the light of morale shatterer!

⁴ Throughout this survey, spot checking was conducted almost every month by exposing badges to gamma rays from known radium sources, and by comparing film badge readings with the related calculated doses. This checking never showed a discrepancy beyond ± 15 per cent, with most readings falling within 10 per cent. Pocket chambers and portable survey meters were regularly checked against radium gamma rays.

Concerning the film badges showing more than the maximum permissible dose (M.P.D.), the following comments are pertinent:

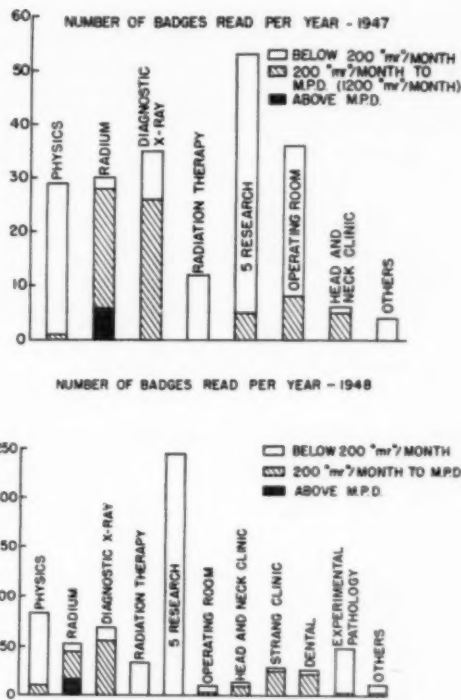
(a) The number of these high readings is small, compared to the large number of film badges used, and has remained almost constant throughout the entire period (1947-54), although the number of film badges worn has increased more than tenfold.

(b) Such high readings seldom, if ever, exceed 1,500 mr/month.

(c) For the entire period (1947-54), approximately seven-tenths of all badges showing high readings were worn by radon-plant operators (during periods of training only), and two-tenths were worn by diagnosticians (generally during the first few months of residency). Readings were always obtained outside a conventional lead-rubber apron (0.5 mm. lead) routinely worn by both diagnosticians and radon-plant technicians. The corresponding readings under the apron never showed anything approaching the M.P.D., and in no single instance did the yearly average approach one-half M.P.D.

(d) For the remaining cases—12 for the entire period (1947-54)—all high readings, with one or two exceptions, were caused by tampering with the film packet, wearing the film badge during an x-ray examination, or exposed to either heat or steam or both. A single interesting case which took a little time to trace occurred a few years ago. The badges of two floor maids showed high readings, obviously due to low-voltage x-rays, though there was no record of these maids having been subjected to x-ray examination during the period involved. After persistent inquiry, it was found that they had taken it upon themselves one night to operate, for their amusement, a portable diagnostic x-ray apparatus that had been left on their floor. Naturally, the necessary recommendations and provisions were made to prevent any further occurrence of this nature.

2. Figures 2 to 9 inclusive show by years the number of film badges used by



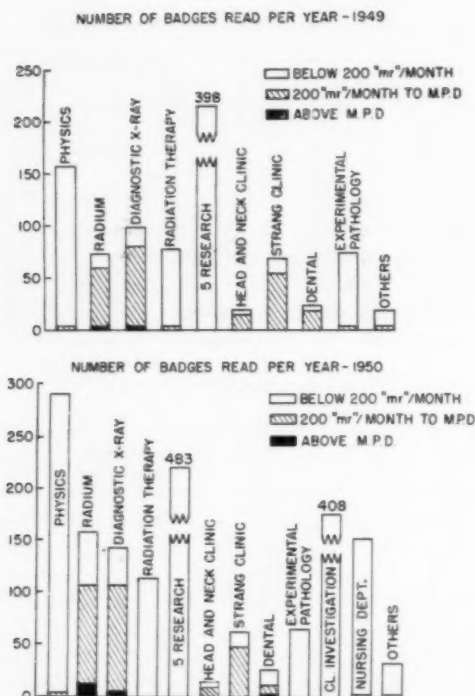
Figures 2 and 3

each department, and doses involved in three arbitrary ranges: below 200 mr/month; 200 mr/month to M.P.D.; and above M.P.D.

Since the readings of the film badges employed were derived from calibration with gamma rays from known radium sources or their equivalent, these readings require interpretation when they represent radiations to which the original calibration does not directly apply. This is generally the case for gamma and x-rays below about 300 kev and for beta radiation. Thus, our data related to diagnostic x-rays have been conservatively "normalized" in accordance with the best information available to us.⁶

⁶ The actual readings under the 1-mm. cadmium shield have been multiplied by 10 in all our data related to diagnostic x-rays; this is approximately equivalent to dividing the "open window" readings by 5.

⁷ Deal, L. J., Roberson, J. H., and Day, F. H.: Roentgen-Ray Calibration of Photographic Film Exposure Meter. *Am. J. Roentgenol.* 59: 731-736, May 1948.



Figures 4 and 5

The obvious deductions to be drawn from these figures are:

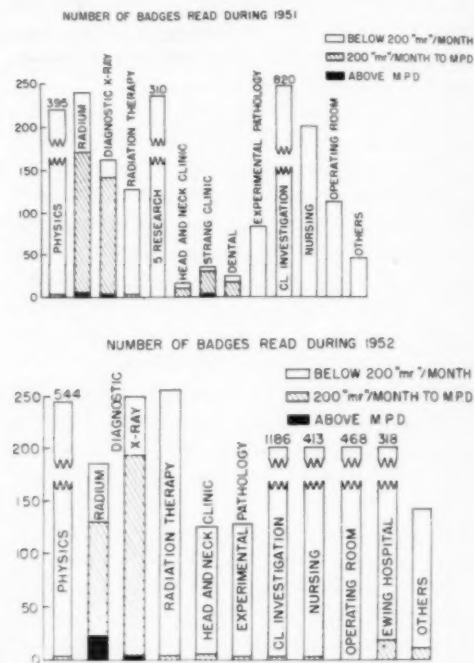
(a) The number of film badges used increased rapidly and consistently until 1952.

(b) Most readings fall in the class of less than 200 mr/month, with very few of these indicating anything above background fog. This class predominates in almost all departments, with the exception of Radium and Diagnostic X-Ray. In this respect, the Strang Prevention Clinic and the Dental Department could be classed under Diagnostic X-ray, because this is the only type of radiation employed therein, while the Head and Neck Clinic could be classed under Radium, because the only sources of radiation employed there are radon seeds.

(c) The next class, relatively small, covers the group of film badges showing between 200 mr/month and 1,200 mr/month, with few showing above 500 mr/month. This class predominates in the Radium Department, Head and Neck Clinic, Di-

agnostic X-Ray Department, and in the Strang Prevention Clinic and Dental Department.

(d) The last, and smallest, class is the group of film badges registering above 1,200 mr/month. As already mentioned, seven-tenths of these film badges were worn by radon plant technicians, and two-tenths by



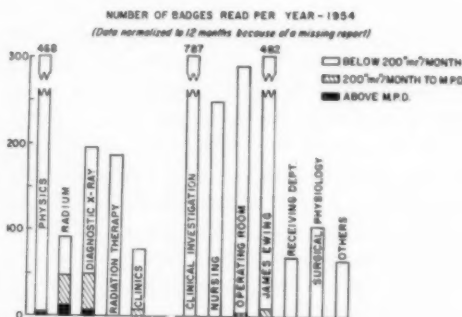
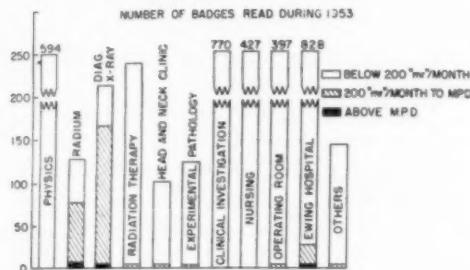
Figures 6 and 7

agnostic X-Ray Department, and more important, these high readings always refer to badges worn outside a conventional lead-rubber apron, and to training periods. For radon-plant operators, the corresponding readings under the lead-rubber apron are about one-half of those outside the apron, as shown in Figure 10.⁷ For di-

⁷ There is a striking degree of agreement between the film badge readings (open-window and under shield) and those obtained by means of pocket ionization chambers, when both are worn by radon-plant operators inside the lead-rubber apron. There is no equally good agreement outside the lead-rubber apron—probably due to scatter from it; if no lead-rubber apron is worn, the agreement is also good. The dose to the hands of these technicians, as determined by additional wrist badges is, surprisingly perhaps, of the same order of magnitude as the whole-body dose, with slight exceptions during periods of training.

agnosticians, the readings under the apron are only a small fraction of those outside the apron.

(e) The increasing use of radioactive isotopes (almost exclusively in departments divorced from the use of radium and radon) has not disclosed exposures anywhere comparable to those related to



Figures 8 and 9

the routine use of radium, radon, and diagnostic x-rays; but it has necessitated a much greater use of film badges, and some watching. The advent of the betatron has not led to any radiation exposure of personnel significantly above background.

3. Figure 11 shows the correlation between the daily readings of pocket ionization chamber and film badge for the radium technician in charge of radium and radon appliances (preparation, distribution, and dismantling) and storage of sources (radium and radon). Every source that this technician handles incorporates no less than 0.5 mm. platinum filtration or its equivalent, with the exception of radon seeds, which incorporate 0.3 mm. gold. On the average, the radium technician handles 400

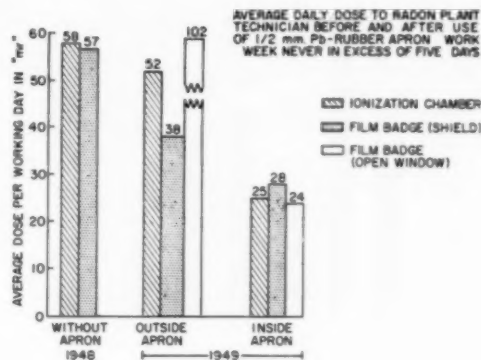


Figure 10

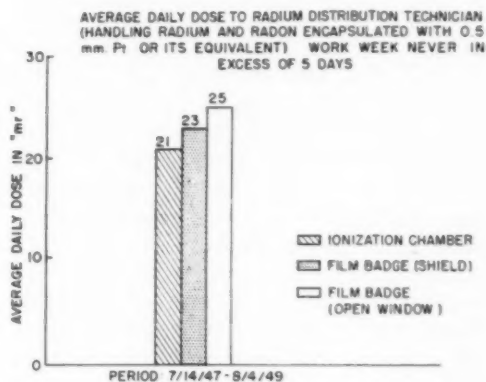


Figure 11

mg. radium, 1,000-mc radon tubes, and 600-mc radon seeds per week. He works five days per week and forty-eight weeks per year; his average dose, as shown by both film badges (two) and pocket ionization chambers (two), is 23 mr/working day, or 115 mr/week. Although this technician does not wear any lead-rubber apron, his whole-body dose is about one-third the M.P.D.⁸

One of the reasons why we sought—and eventually were authorized to give—a radiation training course for nurses handling radium and radon appliances, and caring for patients being treated with radioactive materials, was our correlation of

⁸ There is consistent agreement between readings of pocket chambers and film badges. The dose to the hands of this technician, as determined by additional wrist badges, is of the same order of magnitude as the whole-body dose.

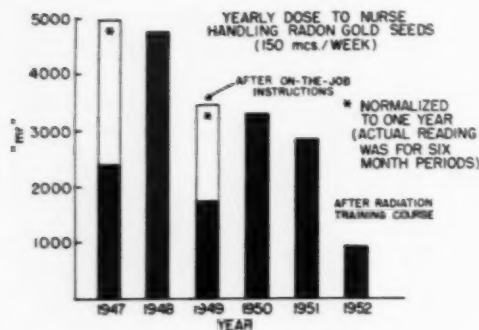


Figure 12

the dose received by some of these nurses with the dose received by the radium technician. We had observed that some nurses who handled less than 10 per cent the amount of radium and radon handled by the technician showed readings as high as his, and occasionally even higher.

4. Of the nurses handling radium and radon appliances one was regularly handling about 150-mc. radon seeds per week, and her average dose was close to 100 mr/week over a period of eighteen months. During this time we had given this and other nurses, and their superiors, a good deal of written material on the subject of safe handling of radium and radon, without much result. We then tried another approach; occasionally, and unobtrusively, we observed this nurse at work and gradually gained her confidence. Meantime we began to suggest such changes in her technic as trying different forceps, using a better lead L block that we supplied and a more suitable work table, and relocating the table with respect to her other stations. Soon she was freely asking our advice whenever she felt in need of it. Figure 12 shows data obtained in the years 1949, 1950, and 1951, illustrating the results of this "on-the-job instruction." Early in 1952, this nurse was in our first two-week training group. The further decrease of dose in 1952 is perhaps indicative of the results of her experience in our department. She was then promoted and no longer available for handling radon seeds, but she must have passed some of her knowledge

on to the next person, as we have seldom seen readings as high as the original ones for this job. Unfortunately, we cannot present comparable data for other nurses, either because of short periods of service or uncertainty as to the amount of radioactive material handled, or both. It seems,

TABLE I: YEARLY AVERAGE OF RADIUM AND RADON HANDLED IN 1950-54

Radium	
Total mc used.....	20,000
Total mc handled.....	30,000
Radon tubes	
Total mc used.....	8,000
Total mc collected.....	50,000
Total number produced.....	400
Radon bulbs: mc collected.....	1,500
Radon "gold seeds"	
Total mc used.....	7,000
Total mc ordered.....	16,000
Total mc produced.....	28,000
Total number produced.....	16,000
Total mc radon collected.....	90,000
Total mc radium and radon handled...	120,000

however, to be generally accepted that two weeks experience in our department on the part of a relatively few nurses was beneficial to all concerned.

In the operating room and examining rooms, the general level of exposure dropped appreciably after the training of the first few nurses working there, although the amount of radium and radon handled did not decrease. But nurses come and go, and it would therefore seem that there is need for an organization analogous to the I.V. Service,⁹ efficiently set up and maintained. The sporadic training of a limited number of nurses, and their indiscriminate employment, will not provide the maximum benefit to the institution.

5. For the period 1950-54, the yearly average of radium and radon handled is shown in Table I. The yearly average of man-produced radioactive isotopes used

TABLE II: RADIOACTIVE ISOTOPES USED: YEARLY AVERAGE FOR 1950-54

Gamma emitters (mostly ^{131}I and Au^{198})...	15,000 mc
Beta emitters (mostly P^{32} and S^{35}).....	1,700 mc
TOTAL.....	16,700 mc

in the same period is shown in Table II. Correlating these tables with the data in Figures 2 to 12 inclusive, one can easily

⁹ Blood Transfusion Service, part of Blood Bank.

see that, as a rule, the higher doses are received by the persons handling the larger amounts of radioactivity.

Although we have not mentioned internal radiation hazards related to the mis-handling of radioactive materials commonly used in hospitals, this aspect of the problem has not been neglected. There have been minor accidents and an occasional ado, always beyond our immediate preventive control, and almost always attributable to inadequate knowledge or skill, or to negligence on the part of some of the users of isotopes. However, at the cost of doing some cleaning and other menial jobs, we were able to avoid any serious situation. Actually, even these slight irritations could be eliminated, and several times as much radioactivity as heretofore employed could be handled, with no greater facilities, personnel, or control measures than at present, provided more key personnel were as careful in handling radioactive isotopes as they are enthusiastic in the prospect of their use.

Almost always, we have managed to know where and when radioactive materials are used throughout the institution, but we have seldom interjected our presence unless it was requested or deemed necessary. The period during which attempts were made at hiding mishaps seems to be long past; now almost everybody consults with us beforehand and even insignificant accidents are reported.

In addition to monitoring of personnel, we have surveyed areas and performed operation analyses. We have also collected, stored for as long a time as necessary, and properly disposed of all contaminated linen, instruments, wastes, carcasses, glassware, etc., thus preventing contamination as much as possible.

We have also tried to anticipate and prevent situations that might cause damage to materials sensitive to ionizing radiations or adversely affect procedures based on delicate radiation measurements. Indeed, considerations of this nature may often be more restrictive than health hazards, especially in crowded quarters and

TABLE III: APPROXIMATE MONTHLY COST OF RADIATION HAZARD SERVICE

1. One associate attending physicist, two radium technicians, one secretary—one-fourth time each.....	\$400
2. Film badges: 300 per month at \$0.40 each.....	120
3. Portable monitoring instruments, \$2,000 amortized over a period of five years, and related maintenance.....	50*
4. Disposal of contaminated carcasses and other miscellaneous items.....	68
Total.....	638
Average per person monitored.....	2.13
Average per employee (approximately 2,500).....	0.26

* This figure is quite liberal, since the original instruments are still in use and in good working order. The shown amortization is approximately \$33.50 per month, with the balance, \$16.50, used for the maintenance of these instruments.

with adventitious personnel. Our "intelligence branch" once missed the apparently innocuous relocation of a large stock of x-ray film (not belonging to our department). The new storage area was close by the platform where radioactive materials are received, and occasionally kept for hours or stored overnight. A sizable part of this stock was spoiled; yet there never was any health hazard to anybody working in this area, as shown both by film-badge readings and by area survey.

COST OF RADIATION EVALUATION AND CONTROL

Table III shows the approximate cost of this service, conducted on a part-time basis by one associate attending physicist, two radium technicians, and a secretary. It is apparent that this cost represents only a small percentage of the expenditures for personnel and operations covered by the service. One can easily infer that such a service would cost appreciably more if it were conducted on a different basis.

It may be worth while to mention that keeping good records of radiation hazard evaluation and control is as demanding on those concerned as it is important. In devising our own method of "bookkeeping," the main objective was to record all information useful not only for immediate needs, but for future evaluations and

contingencies as well. Accordingly, as much information as practicable is systematically recorded relative to (a) dose received, and duties, location, exposure time, and quality of radiation for each person monitored; (b) monitoring and surveying devices used and techniques employed; (c) operation history of each area surveyed; (d) observations and recommendations made. This information is entered in bound record books with numbered pages and on duplicate report sheets, copies of which are sent to the heads of the departments concerned. Furthermore, personnel data are also entered on individual 5 X 8-inch cards, filed alphabetically and by department. Similar records are kept for contaminated items and their disposal. Whenever warranted and feasible, as in the case of radon-plant operators and radium technicians, individual daily logs of operation are also kept.

No monitoring films and related reports are discarded; rather, they are stored in the inactive file at the end of the year to which they apply. All records, monitoring films, and related books are kept under lock and key.

SUMMARY

1. The medical use of man-produced radioactive isotopes and high energy particle accelerators does not appear to present any essentially new problem to the radiological physicist, especially if he is already familiar with the handling of radium and radon and conventional x-ray therapy apparatus.

2. Radium and radon and x-rays in fluoroscopy are still the major sources of external-radiation hazards in hospitals. By comparison, the external hazard from radioactive isotopes is minimal, with the exception of cobalt-60 and gold-198, used instead of radium and radon.

3. Internal-radiation hazards arising from the medical use of radioactive isotopes also seem to be minimal, or can so be made, if the radiological physicist is familiar with their handling and fully gains the

confidence and co-operation of all concerned.

4. All radiation hazards can be minimized, and kept well within the applicable permissible limits (a) without special administrative powers; (b) without experts in new fields; (c) without unduly elaborate facilities. Much depends on planning and training. Personal aptitudes remain paramount.

5. In some instances, the possible damage to sensitive emulsions and interference with delicate radiation measurements may be more restrictive than the contemplated health hazards.

6. Although our data and conclusions will not always apply in other hospitals, they nevertheless give some idea of hazards that can be expected, practicable control measures, and costs. This knowledge may be helpful in placing the problem of radiation hazards in its proper perspective.

7. The cost of radiation protection in a hospital can be kept within modest limits.

ACKNOWLEDGMENTS: We gratefully acknowledge our indebtedness to Mr. L. D. Marinelli, Attending Physicist and Chief of the Department of Physics, Memorial Hospital, New York, at the beginning of this project, for his unfailing and invaluable guidance, and to Mr. L. S. Taylor, Chief of the Atomic and Radiation Physics Division, National Bureau of Standards, Washington, D. C., for his interest and generous help in the preparation of this paper.

Our thanks are also due to Dr. G. Failla for facilitating our work through his farsighted design of radiological facilities at Memorial Hospital and his unfailing guidance.

Last but not least, we thank the staff of the Art Department of Memorial Hospital, and Elaine Pfeiffer of the Upstate Medical Center at Syracuse, for their assistance in preparing this manuscript.

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* This article came to our attention after this paper was presented.

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(Para el sumario en español, véase la página siguiente.)

SUMARIO

Justipreciación de los Riesgos y Dominio de la Radiación en los Hospitales

En lo tocante al hospital, la esfera de la protección radiológica abarca todos los procedimientos prácticos, convenientes y económicos que hagan la aplicación médica de los rayos yonizantes razonablemente inocua para los enfermos, el personal y el público en conjunto.

El radiofísico, encargado de esa misión, tiene que combinar los conocimientos técnicos con la comprensión de las funciones y la vida del hospital. Es de su incumbencia analizar los problemas de protección contra la radiación; formular las recomendaciones que sean necesarias acerca de los riesgos potenciales o reales; concebir o procurar el equipo necesario para llevar a cabo operaciones que entrañen peligro derivado de la radiación; poner en efecto procedimientos previsores y exploradores; descartar los desechos contaminados.

El empleo médico de isótopos radioactivos y de aceleradores de partículas dotadas de alta energía, de creación humana, no parece plantear un problema esencialmente nuevo al radiofísico, máxime

si ya está familiarizado con la manipulación del radio y del radón y con los aparatos corrientes de roentgenoterapia. El radio y el radón, y los rayos X en la roentgenoscopia, todavía constituyen las grandes causas de los riesgos de la radiación externa en los hospitales. En comparación, el riesgo externo derivado de los isótopos radioactivos es mínimo, con excepción del cobalto-60 y del oro-198, cuando se usan en vez de radio y de radón.

En algunos casos, el posible daño a las emulsiones sensibles y la perturbación de delicadas mediciones de la radiación pueden resultar más restrictivos que los riesgos corridos por la salud.

Aunque los datos y conclusiones del A., basados en su propia experiencia, no rezarán siempre con otros hospitales, darán, sin embargo, alguna idea de los riesgos que cabe esperar, así como de las medidas prácticas de dominio y del costo. Esta información puede resultar útil para colocar el problema de los riesgos de la radiación en su propia perspectiva.

DISCUSSION

Carl B. Braestrup (New York): Mr. Ferlazzo and his co-workers have demonstrated clearly that it is possible to obtain an extremely high degree of radiation safety in hospitals. As shown by them, it requires first of all intelligent efforts, a certain degree of discipline, and a relatively small expense.

The authors have justly emphasized that the newer forms of radiology have not increased the radiation hazards. We have found that among radiological personnel, isotope technicians and operators of cobalt teletherapy equipment receive about the lowest doses. Our experience with personnel monitoring is very similar to that reported. Our program covers about thirty hospitals and almost 700 radiation workers. Of the latter, 80 per cent average less than one-twentieth and 92 per cent less than one-tenth of the maximum permissible dose. Only 2 per cent of all returned badges show that the maximum permissible dose has been exceeded. In such cases immediate steps are taken to rectify the

condition. Usually it is due to improper procedures, such as holding patients during radiography.

Today the exposure of radiological personnel has been reduced to such a level that we consider 200 mr/month sufficiently above average to warrant investigation. Yet such doses are relatively insignificant if we consider the large group of medical installations which operate without proper safeguards. I am referring here to x-ray equipment installed in the offices of general practitioners and non-radiological specialists and used without regard to radiation safety. An internist recently lost his hand as a result of many years of fluoroscopy. He had done all of his examinations with maximum field size and apparently with his hand in the un-attenuated beam. No doubt other doctors are doing exactly the same thing today. Of equal importance is the excessive irradiation of the patient in such cases. Here, I believe, is a fertile field for education in radiation protection.

Radiation Protection in the Atomic Energy Industry

A Ten-Year Review¹

H. M. PARKER, M.Sc., F.Inst.P.

OPERATION OF the first nuclear reactor dates back to December 1942. By 1944, production nuclear reactors for the manufacture of plutonium were in use at the Hanford Works (Richland, Wash.). The purpose of this contribution is to report on the progress made in radiation protection in such an industry in the past ten years. The scope of the problem can be sufficiently defined by recalling that the radioactivity handled is on the order of millions of times, or tens of millions, that from the available world supply of radium.

ORGANIZATION

The early radiation protection organizations were under medical leadership, a proper arrangement when the degree of direct medical participation could have been large. Experience has shown that such medical participation is minimal. Annual physical examinations and periodic blood counts have their place, but not significantly more so in the atomic energy industry than in other industries. The paramount medical contribution is the expert treatment of the occasional individual who may have been exposed to excessive radiation, externally or internally.

It was natural that leadership of the radiation protection programs should pass to a group of scientists (chiefly physicists) versed in the scientific problems involved and with enough general knowledge of biological and medical procedures to realize when and how expert assistance was needed. This led to the golden age of the health-physicist; we speculated in 1947 that the subject might have approximated its maximum status at that time. To some extent, this has been demonstrated by a tendency in industry to incorporate the radiation protection function with overall

safety and health functions. In many organizations this would appear to be a wholly satisfactory development. It means, however, that the position of the industrial health physicist is limited. Somewhere there must be an atmosphere in which leading scientists in radiation protection can develop the field for future advancement. The principal difficulty involves lack of integration of the research effort with the practical field application of new methods. This difficulty arises in all branches of applied research, when the research effort is separated by organizational barriers from the intended user.

At the Hanford Works, where protection requirements apply to practically every operating task, phase of design, and construction of improved facilities, organization has developed along different lines. A few years ago, responsibility for radiation monitoring was detached from the radiation protection organization and integrated with all other responsibilities of the manufacturing organization. This change reflects the attitude that ultimately each operator must take care of his own radiation monitoring, just as he protects himself by not walking under a ladder or by not handling acid without protective equipment. The industry, however, is not yet ready for this step. The individual operator does not yet take care of his own radiation hazards; he requires a higher percentage of trained monitoring support than at any previous time.

The percentage of the radiation monitoring force in relation to the total operating force in the past ten years has been as follows:

First four years of operation	1.3%
Three years prior to decentralization . .	2.2%
Three years since decentralization	2.8%

¹ Presented as part of a Symposium on Radiation Protection at the Fortieth Annual Meeting of the Radiological Society of North America, Los Angeles, Calif., Dec. 5-10, 1954. Work done under General Electric Contract W-31-109-Eng-52 to the Atomic Energy Commission.

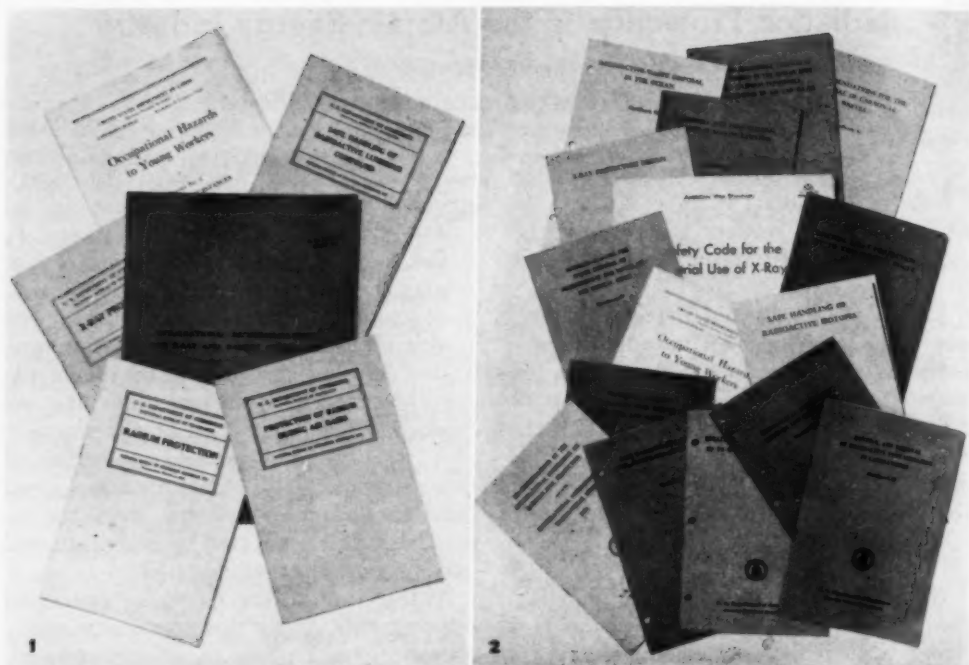


Fig. 1. Handbooks of radiation protection recommendations as of 1944.

Fig. 2. Handbooks of radiation protection recommendations as of 1954.

STANDARDS

At the beginning of the review period, the controlling standards, *i.e.*, the recommendations of the former Advisory Committee on X-ray and Radium Protection, were few in number and generally were tailored to the experience and needs of hospital practice (Fig. 1). Today there is a library of handbooks containing the recommendations of the National Committee on Radiation Protection² (Fig. 2). The complexity of these standards arises largely from the many phases of hazard problems in dealing with radioisotopes; no fewer than seven handbooks (42, 48, 49, 52, 53, 56, 58) are wholly concerned with this field. Moreover, the values given in these publications do not have the comfortable assurance of ordinary engineering

² The interest that the Atomic Energy Commission and its principal contractors have shown in the establishment of adequate standards is significantly demonstrated by the fact that almost half the membership of the subcommittees of the National Committee on Radiation Protection is derived from this source.

standards. The data of *Handbook 52*, on maximum permissible concentrations in air and water, are particularly vulnerable and are recognized to have at least the following defects:

1. Too few values are based on actual radiation damage experience in man.
2. Values for the bone-seeking isotopes are conventionally based on hazard ratios of the specific isotope to radium in animals, together with human data on radium. Hazard ratio changes as one proceeds from acute to chronic exposures. Specific questions are the significance of the different life span in animals and, to the severe critic, the validity of extrapolation of any biological data to man.
3. Values for other isotopes are based on simple physical concepts using uptake, deposition, and retention data from animal experimentation. Such data are suspect because of: (a) non-uniform deposition in the alleged critical organ; (b) dependence on chemical form, such as valency, pH, and presence of complexing agents; (c) dependence on physical form, such as particulate nature; (d) probable invalidity of the assumption that the same average dose is appropriate for all organs.
4. Choice of the critical organ is equivocal. Irradiation of the gastrointestinal tract has usually not

been considered in *Handbook 52* limits for water contamination.

For some nuclides of practical interest, the factor of disadvantage for irradiation of the bowel is as high as 1,000, and for more exotic cases as high as 40,000. Yet uncompromising switch to the intestine as the critical organ would unnecessarily hamper the great majority of practical applications of limits for water.

5. Limits currently given apply to direct application of drinking water or inhaled air to man. These limits are not always the defining ones even for such familiar isotopes as I^{131} and P^{32} . If radioiodine were released to the atmosphere so that a large area was maintained at the permissible concentration for breathing, vegetation would become so contaminated with the isotope that its consumption by range animals would be hazardous. Similarly, if P^{32} were maintained in a public water way at the formal permissible limit, its concentration in plankton and algae and its transmission to fish through food chains would be sufficient to create a hazard to a successful fisherman.

6. The whole question of limits for mixtures is in doubt. Multiple critical organs are involved, and there may be synergistic effects.

These illustrations are not criticisms of the existing standards. Rather, they indicate that the standards field is becoming increasingly complex and is not ready for formal codification. Each major application must be studied as a separate research problem.

MECHANICAL TOOLS OF THE TRADE

Among mechanical tools of the trade one can group radiation detection instruments, mechanical devices for the safe handling of radiation equipment, and protective clothing.

A full account of the advances in instrumentation would occupy more than the allotted space for this review. In brief, in ten years the field has grown from an array of laboratory-designed equipment, with a few outstanding commercial contributions, to an efficient, diversified, and highly competitive branch of the instrumentation industry.

For the present purposes, one can divide instrumentation into (a) portable dose-rate meters, (b) portable contamination meters, and (c) fixed instrumentation, including hand counters, air sampling equipment, and supporting laboratory equipment.

Under category (a), the 9 types of meters used in the first two years of operation at the Hanford Works became obsolete in an average period of five years. By excluding two exceptional types that are still used the obsolescence period is reduced to three years. Under category (b), 7 original types persisted for an average period of five years. Under category (c), where the more taxing requirements of battery operation, small size, low weight, and ruggedness of portable meters are not required, the average life of 10 types has been seven years.

In addition to the progress measured by the tangible yardstick of obsolescence, there has been notable advance within many of the types in the direction of improved circuit stability, reduced time constant, reduced battery weight, reduced extracamerai ionization, simplified calibration, and improved decontaminability. At present, the radiation monitoring equipment field appears to be in the middle of another transition period, which will lead to the application of scintillation meters to almost all monitoring situations, with significant gains in ease of maintenance.

In the field of mechanical devices for handling radioactive materials without exposure to radiation beams, there remains no problem of interest to industry except that of cost reduction. The three questions of adequate shielding, transmission of sufficiently sensitive motion through shields, and transmission of adequate vision of an operation through shields, were all solved in the early days of the atomic energy program. For laboratory operation, there has been some improvement in the design of remote manipulators, and the use of high density lead glass has been a desirable addition to methods of seeing through shields.

Mechanical devices which also prevent the spread of radioactive contamination have been far less successful. On the laboratory scale the ingenious enclosed boxes, developed by N. B. Garden and collaborators, have frequently solved the problem. Larger scale applications have rarely, if ever, been successful for an ex-



Fig. 3. The plastic man, an impervious suit with attached exit tunnel for use in grossly contaminated areas. The suit can be left in the contaminated zone so that the offending material is not disseminated. Topologically, such a device is a cross between a barrier around contaminated equipment and a protective suit on a man.

tended period. It is of interest that, in principle, the more complex Garden boxes are remotely operated chemical plants in miniature; the sole reason the miniature plant is highly successful and the large-scale one frequently less satisfactory is that the former can be thrown away if detailed decontamination should become troublesome.

Advances in protective clothing in the ten-year period have been generally disappointing. Substantial improvements have occurred in respiratory protection, where masks were designed for specific tasks. The general question, however, of providing a comfortable garment impervious to liquid contaminants remains unsolved. This is perhaps to be expected, since the ideal solution calls for a lightweight material that will repel all liquid or moisture presented to the outside while freely passing all moisture generated on the inside.

Protective clothing development follows two divergent paths from the earlier conventional cotton coveralls, shoe-covers, etc.: in one direction the aim is a cover cheap enough to permit disposal after a single use; in the other, a material as repellent as possible to the probable contaminants and as easily cleansed as possible of such contamination as does occur.

An extreme example of personnel protection is shown by the well publicized plastic suit with access tunnel (Fig. 3). Although such suits are effective in special cases, their *general* application would be a tacit admission of the basic failure of engineering in the field. Of the choice between placing an impervious barrier around each operator and placing it around the offending equipment, the latter is obviously the ultimate objective.

In thus assuring a clean atmosphere for the operators there is nothing qualitatively different from conventional industrial hygiene control of toxic materials. Quantitatively, the problem may be greatly intensified. This is clearly seen from the representative values of maximum allowable concentrations (MAC), as follows:

Contaminant	MAC p.p.m.
Lead.....	~ 0.1
Typical organic solvents.....	~20
Highly toxic non-radioactive materials.....	~10 ⁻³
Mixed fission products.....	~10 ⁻⁶
Plutonium.....	~10 ⁻⁸
Special fission products.....	~10 ⁻¹¹

The cost of reducing atmospheric contamination by ventilation rises sharply as the cleanliness requirement is increased, and reduction by more than one or two orders of magnitude becomes an absurdity. The following are representative ventilation costs, averages of a number of industrial examples:

Ventilation	Percentage of Cost* of Normal Facility
Comfort only.....	~ 10%
10-fold dilution.....	~ 180%
100-fold dilution.....	~1000%

* Includes initial cost and operating costs. Normal facility, as used here, means one in which ventila-

tion requirements are provided for human comfort only.

MENTAL TOOLS OF THE TRADE

The need for and availability of professional and semiprofessional skills represents another phase of radiation protection. Outstanding progress has been made in this field in ten years. At the beginning of the period the qualified leaders were few in number and came generally from a common background of association with radiotherapy. Today, significant contributions to hazard control are being made by scientists and engineers who have had no contact with radiology. Formal training programs have helped develop an adequate corps of men in the intermediate field of technical attainment. From this corps should come the leaders for the next decade, men who can combine an understanding and appreciation of research developments in protection with a practical interest in and application to working requirements of industries and laboratories.

At the lower echelons of control is a general movement toward development of a recognized craft of radiation monitoring, which leads to one successful method of operation (in principle perhaps not the best, but in practice probably so), provided close support of technical specialists is available. Since a high percentage of day-to-day control of hazards is founded on common sense rather than highly specialized technical experience, and since common sense is by no means a monopoly of the academically trained, it is not surprising that excellent contributions to detailed control should have come from a force of radiation monitors.

The required research and development in radiation protection have been crystallized in the ten-year period. As applied to an operation such as the Hanford Works, this includes studies in the following fields:

Field	Principle Objectives
Radiobiology	Realistic maximum permissible exposures to man, range animals, aquatic life, wildfowl, plant life, etc.

Radiation biochemistry	Uptake, deposition, and retention of radioisotopes.
Pharmacology	Toxic effects of radioisotopes; methods of treatment.
Radiological physics	Dosimetry of radiation.
Instrument development	Improved instrumentation for monitoring and radiation research.
Meteorology	Atmospheric pollution control.
Industrial hygiene	Behavior of particulate matter in the atmosphere.
Soil science	Retention of radioactive wastes by earth materials
Hydrology	Transmission of underground wastes.
Chemistry; chemical engineering	Chemical dosimetry; sampling and analytical techniques.

At the Hanford Works, these activities are integrated under the arbitrary title of Radiological Sciences. To develop necessary skills, specialists in the separate fields, usually without prior radiation experience, have been introduced to the radiation protection background of the parent organization under conditions which may tempt them to be critical of the sometimes biased outlook of the earlier radiological scientists. This cross-fertilization, both here and elsewhere, has brought many novel concepts to the whole field.

OPERATING RESULTS

For administrative purposes, radiation exposure incidents can be conveniently classified as follows:

(1) *Serious Overexposure*: Cases in which the tolerance status of an individual may be affected (as used in *Handbook 59*).

(2) *Technical Overexposure*: Cases in which exposure exceeds one of the recommendations of *Handbook 59* (or other appropriate recommendations).

(3) *Potential Overexposure*: Cases in which technical overexposure could have been received under similar circumstances; these minor incidents, documented for teaching and control purposes, serve to indicate the need for revised control methods.

In all cases, it is constructive to separate the cause into (a) radiation beams and (b) radioactive contamination. Table I shows

TABLE I: AVERAGE NUMBER OF INDIVIDUALS "OVER-EXPOSED" PER YEAR

Period	"Over-Exposure" Type				Potential Rad. Con.	
	Serious Rad.	Con.	Technical Rad.	Con.		
Early	0	0	3	1	9	24
Middle	0	0	1	1	10	21
Recent	0	0	9	8	16	32

the average annual experience, with the ten-year period divided into three equal parts.

The absence of entries in the serious over-exposure column is noteworthy. Perhaps more surprising is the failure of entries in the other columns to diminish with time. The reason is at least threefold:

(a) The total risk has increased, as the rate of production of radioactive materials has increased substantially in this period.

(b) Maintenance work, always prone to generate contamination problems, logically increases for older facilities.

(c) The frequency of incidents is controllable by procedures. Thus, improvement in control methods not shown by a decrease in the frequency of radiation incidents actually appears on the record in the form of a *decrease* in individually written radiation work permits, with a decline from an average of 50,000 permits per year in the middle period to 15,000 per year in the recent period; this represents a substantial administrative saving with no loss of control.

In conformance with national policy, employee exposures to external radiation were originally subjected to controls of a daily limit, and more recently to those of a weekly limit. Of some significance is the long-term control on the basis of an annual limit. The accepted annual exposure to gamma radiation is 15 r. The self-imposed control at this location is 3 r per year. Average annual exposure has been far below this, as shown in Table II.

Favorable scores in average annual exposure can be achieved by including enough people whose expectation of exposure is very small; to some extent, the data of Table II include such dilution. Therefore, one must present some information on the

TABLE II: AVERAGE ANNUAL EXPOSURE TO GAMMA RADIATION

Year	Annual Exposure, (r)	Percentage Exceeding 1 r	Percentage Exceeding 3 r
1944-45	0.9	0.2	0
46	0.6	0.2	0
47	0.4	0.3	0.02
48	0.3	0.2	0
49	0.2	0.08	0
50	0.1	0.06	0
51	0.1	0.4	0
52	0.2	3	0.02
53	0.2	5	0.07
54 (projected)*	~0.2	~3	~0.05

* Note added in proof: Actual figures for 1954 were 0.2, 5, and 0.2 respectively.

highest cases. This has conventionally been done at Hanford by reporting the 10 highest annual exposures to gamma radiation each year. These averages are:

1945.....	1.3 r
46.....	1.4 r
47.....	1.9 r
48.....	1.4 r
49.....	1.0 r
50.....	1.0 r
51.....	1.4 r
52.....	2.6 r
53.....	3.1 r
54 (projected).....	4.0 r

It is evident from the data of Table II and the figures just given that control of external radiation in the atomic energy business presents no problems and can demonstrably be manipulated to levels that interpret the phrase "lowest practicable level" of *Handbook 59* to include economic incentive to avoid extremes of control.

Control of internal deposition is not so easily manipulated. Contributing reasons are: (a) difficulty of prompt signalling of an exposure; (b) greater uncertainty of deposition limits; (c) uncertainty of bio-assay interpretation as to when an assumed dep-

TABLE III: INTERNAL DEPOSITION OF RADIOISOTOPES

Period	Positive Cases per Year	Positive Cases per Year (Reduced to Consistent Detection Limit)	Cases Above Appropriate Limit
Early	0	0	0
Middle	1	1	0
Recent	30	6	2?

osition limit is being approached; (d) inability to remove the source in most cases.

The incidence of positive cases of deposition has risen as shown in Table III. The two entries in the last column refer to cases which in fact are probably below appropriate limits, but in which there is still some uncertainty of interpretation.³

Operating results with respect to release of radioactive effluents to the atmosphere or to public water supplies have been demonstrated in scientific exhibits at two previous meetings of the Radiological Society of North America. It will be sufficient to point out here that all these problems have proved to be controllable with adequate safety margins. In order to operate at the best economic level, it is necessary to maintain extensive regional monitoring programs supported by research studies.

FUTURE PROBLEMS

There are two significant administrative problems for the next decade. The first relates to *education and public relations*, and the second to *legislation and regulation*. Opinions on the released information on atomic energy hazards range all the way from the implication that the drama of the situation has been magnified by enthusiasts to the equally extreme implication that the real nature of the hazard has been deliberately de-emphasized. The public has the right to as full information from existing atomic energy programs as is consistent with prudent control of data from which the atomic potential of the nation could be inferred. The next decade will see widespread industrial application of radioisotopes and the first use of industrial atomic power. Factual information on hazards in both these fields is needed.

This contributor's point of view is suggested in the present review of ten years experience. Foreseeable hazards in external radiation can be controlled with comparative ease. Internal deposition is

also controllable through the use of safety factors which may prove to be excessive when further research has crystallized appropriate limits for specific cases. The atomic energy industry started safely at the expense of considerable investment in radiation protection, and it can be safely continued.

There is an inherent fear in some quarters that it is one matter to spend government dollars on protection and quite a different matter to spend stockholders' dollars. In the present era of enlightened business management, the writer believes this fear to be ill-founded.

Regulation of radiation hazards will receive much attention in the coming period, and the manner in which it is carried out may affect the nation's rate of progress in atomic energy. Traditionally the National Committee on Radiation Protection has emphasized the advantages of control by recommendation *versus* control by statute. The recent appointment of a subcommittee to prepare model codes for state legislation presumably represents an admission that self-regulation by recommendation will not be powerful enough to assure control in a rapidly expanding field. Since the intelligent management of hazards, especially as it affects the public in terms of waste disposal, is heavily conditioned by local circumstances, it will prove extremely difficult to write generalized codes that are sufficiently restrictive of all radiation operations, without being absurdly over-restrictive of the majority.

It appears probable that unduly restrictive codes will be written. The key to progress will then hinge on the manner of interpretation and enforcement. There are good precedents in related fields, such as water pollution, for adequate and enlightened control as opposed to literal interpretation. A major disadvantage of this approach is that the large and reputable manufacturer may tend to stay within the most rigorous possible interpretation of every code clause, regardless of cost, in defense of his reputation; the marginal operator would be much less likely to

³ Note added in proof: These 2 cases are now known to be below permissible limits.

accept the more expensive interpretation. To some degree, this can place the emphasis of restrictive control on the organizations most likely to maintain voluntary control at a demonstrably reasonable level for the specific case.

The fundamental problems in radiation protection remain unchanged. Typical questions and the practical corollaries are:

1. What is the basic nature of the interaction of radiation with living matter? Would knowledge of this lead to a generalized scheme of protection or to methods of moderating exposure effects?

2. What is the origin of radiation carcinogenesis? Under what conditions, if any, can a single radioactive focus in the lung, for example, induce a malignant neoplasm?

3. What is the precise significance of the genetic effect in man?

4. Can the total residual insult, say for a single radiation type, be integrated by a plausible formula to cover all cases between the extremes of a single acute exposure to a uniform chronic exposure?

5. Under what conditions are the effects of mixed radiations additive by some determinable formula? Can such a concept as the *rem* be fruitfully extended?

Applied problems of principal concern include the following:

1. How can exposures to mixed radiations be adequately integrated in the field?

2. What are the appropriate permissible limits for a wide variety of radioisotope exposures in man and other life forms?

3. How can organ exposures to low-energy emitters be determined? In particular, how can lung deposits be determined, and how can bio-assay results be reliably related to body deposition?

4. What pre- or post-exposure methods can be developed to reduce radiation injury?

The engineering problems related to protection are primarily:

1. How can radioactive materials on the industrial scale be completely contained at source?

2. How can radioactive waste be

permanently contained on an economic basis?

3. While remote operation and maintenance of major equipment is feasible, initial cost is high and maintenance tends to be slow and costly. If Problem 1 cannot be solved, can effective rapid decontamination be developed to make contact maintenance attractive?

4. Again assuming that Problem 1 is not completely soluble, what standards of air cleansing, both within operating plants and for releases to the atmosphere are necessary and adequate? How can such standards be reached economically?

5. As applied to the nuclear power industry, can reactors be designed and operated with *absolute* assurance that there could be no catastrophic accident, so that they could be placed in metropolitan areas?

6. How can irradiated materials (e.g., reactor fuel elements) be safely and economically transported to processing locations?

In summary, one can say that the fundamental problems of radiation protection are precisely those that have perplexed the inquiring radiologist and radiobiologist since radiation sources were first used. The new emphasis introduced by the atomic energy program is the need for solutions to these problems for mixed radiations.

In the applied problem and engineering areas, the emphasis is predominantly on the elimination of radioactive contamination and on the interpretation of contamination hazards on the body, within the body, and in many other life forms.

It seems to the writer that the next decade will see substantial reduction in the release of effluents to the atmosphere, with some progress in control of in-plant contamination. It appears unlikely that absolute success will be achieved in either field. Therefore, the chief expected burden in radiation protection will probably be in more and more refined interpretation of minimal depositions in man and other life forms. In this way, practical success in control, as opposed to unequivocal success

by complete elimination of the problems at source, is the reasonable objective for the next decade.

Hanford Works
Richland, Wash.

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SUMARIO

La Protección contra la Radiación en la Industria de Energía Atómica: Estudio Decenal

Repásanse aquí los desenvolvimientos en la protección contra la radiación desde 1944, en que se emprendió la producción de reactores nucleares para la fabricación de plutonio en la Sección de Productos Atómicos de los Talleres Hanford. Obsérvese que los problemas fundamentales son precisamente los que han perturbado al radiólogo y al radiobiólogo inquisitivos desde que se usaron por primera vez focos de radiación. La nueva acentuación procede de la necesidad de encontrar soluciones a los problemas de las radiaciones mixtas.

Los riesgos predecibles de la radiación en su aplicación externa pueden dominarse con comparativa facilidad. Los depósitos internos son también dominables por medio del empleo de factores de seguridad que quizás resulten excesivos cuando nuevas investigaciones cristalicen los límites apropiados a casos específicos. En las zonas de ingeniería, se recalca predominantemente la eliminación de la contaminación radioactiva y la interpretación de los riesgos de contaminación sobre el cuerpo, dentro del

cuerpo y en otras formas de vida. ¿Cómo pueden integrarse adecuadamente en el campo las exposiciones a las radiaciones mixtas? ¿Cuáles son los límites tolerables apropiados para una inmensa variedad de exposiciones a radioisótopos en el hombre y en otras formas de vida? ¿Qué métodos pre- o post-exposición pueden elaborarse que reduzcan las lesiones irradiatorias?

Opina el A. que el próximo decenio verá una reducción substancial en la liberación de efluentes a la atmósfera, con algún adelanto en el dominio de la contaminación por implantes, pero que parece improbable que se obtenga éxito absoluto en una u otra rama. Por lo tanto, la principal sobrecarga esperada en la protección contra la radiación consistirá probablemente en una interpretación cada vez más refinada de los depósitos mínimos en el hombre y otras formas de vida. El éxito práctico en el dominio, en contraposición al éxito inequívoco mediante la eliminación total del problema en su foco de origen, representa el objetivo razonable para el próximo decenio.

(For discussion of this paper, see page 891.)

Cinemicrographic Observations and Theoretical Considerations on Reactions of Lymphocytes to X-Rays¹

ROBERT SCHREK, M.D.

PREVIOUS STUDIES by time-lapse cinemicrography (1) showed that irradiated lymphocytes, after a latent period, undergo lobulation and death. This work has been repeated with the use of a new cinemicrographic apparatus which provided additional information in regard to the morphology and death of irradiated and non-irradiated lymphocytes.

Methods: A cell suspension was prepared from the thymus of a rabbit by methods described in another paper (2). The cells were suspended in 50 per cent rabbit serum and treated with 1,000 r from a 200-kv machine. A drop of the irradiated and non-irradiated suspension was placed between two cover slips, separated by a metal disk 0.8 mm. in thickness. The preparation was incubated at 37° C. and photographed.

The cinemicrographic outfit consisted of an inverted microscope equipped with a fluorite, phase-contrast, oil-immersion objective 45X, N.A. 0.95. The microscope was enclosed in a Lucite incubator which maintained a temperature of 37° C. A 16-mm. moving picture camera with time-lapse equipment was mounted in front of the microscope. Pictures were taken on negative film at the rate of 1 frame per two to six seconds. The magnification on the film was 170X.

Projection of the cinemicrographic film at the normal speed of 16 frames per second did not permit a detailed study of the film. It was necessary to project at lower speeds and to view and print many single frames. A commercial moving picture projector with a hand drive and a counter to enumerate the individual frames was used to study the film. A voltage transformer was inserted in the electric circuit of the lamp so



Fig. 1. Morphologically normal lymphocytes in an irradiated suspension from rabbit thymus. The prints were made from a time-lapse cinemicrographic film. The headings give code letters for the cells and the time of incubation in hours and minutes. The orientation of the cells in this and other figures is the same as in the moving-picture film. Magnification $\times 1750$.

that the light could be controlled to minimize heat and to facilitate printing. The positive film was studied carefully, and the frames needed for printing were determined and identified by means of the counter. The negative film was then run through and the image was projected downward by means of a first surfaced mirror at a 45° angle. By this means 3 X 4-inch prints were made from the 16-mm. film. The final magnification was then 1,750X.

RESULTS

Irradiated Lymphocytes: On the projected cinemicrographic film the irradiated lymphocytes at first seemed normal in appearance and in behavior. Figure 1 shows still prints of two morphologically normal cells labeled E and F and gives the duration of incubation in hours and minutes. It is seen from the figure that the lymphocytes had large, round or oval nuclei with distinct nuclear walls. Several large dark granules are visible beneath the nuclear membrane and in the interior of the nucleus. The granules are apparently chromatin in character, as indicated by their distribution, number, and size. A

¹ From the Tumor Research Laboratory, Research Service, Veterans Administration Hospital, Hines, Ill. Supported in part by a grant-in-aid from the American Cancer Society upon recommendation of the Committee on Growth of the National Research Council, and from the American Cancer Society, Illinois Division. Accepted for publication in November 1954.

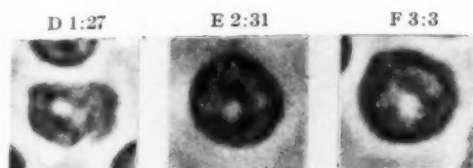


Fig. 2. Early intranuclear vacuoles in irradiated lymphocytes.

small amount of cytoplasm is seen in cell F, which is undergoing ameboid motion. The light halo around the cells is an artefact produced by the phase microscopy. On projection of the time-lapse cinemicrographic film, the viable lymphocytes had an active rhythmic, vibratory, brownian-like movement. An occasional lymphocyte showed ameboid motion.

The first change in the irradiated cells was probably the appearance of minute vacuoles in the nuclei, as seen in Figure 2. The early vacuoles were small and had sharply outlined boundaries. In other respects, the vacuolated cell appeared normal. In fact, cell F showed ameboid motion (Fig. 1) after the development of a vacuole (Fig. 2).

The vacuoles were difficult to photograph and study because of the small depth of focus of phase objectives and the rhythmic movements of the living cell. It was therefore rarely possible to follow a vacuole for more than a few successive frames. The small vacuoles were not observed in the cinemicrographic film during projection at normal speeds. They were studied by the projection of individual frames and were best seen in still prints of these frames. In view of the difficulties of photographing and viewing the early vacuole, small vacuoles were not seen in all the degenerating cells.

The first conspicuous change in the cell was the development of irregularities in the shape of the nuclei and the cell outline (Fig. 3). The nuclear walls were crinkled, with small bud-like projections. These changes usually followed the development of small intranuclear vacuoles, as can be seen in cells E and F (Figs. 2 and 3). Occasionally both the small vacuole and a

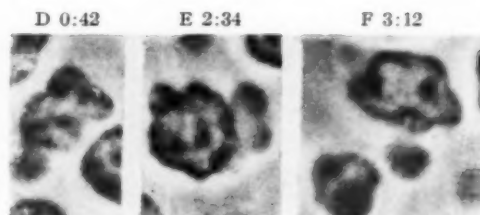


Fig. 3. Irradiated lymphocytes in an early stage of degeneration. The nuclei are slightly irregular in shape. The chromatin distribution still appears fairly normal.

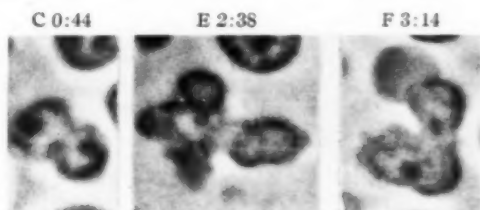


Fig. 4. A later stage of degeneration of irradiated lymphocytes. The cells and nuclei are highly irregular in shape and show early lobulation.

slightly distorted nucleus could be seen simultaneously in the same cell. In the projected film, the change in shape of the nucleus was rapid in onset and development.

The early degenerative stage with its minor changes in shape of the nucleus and cell was soon followed by progressively more drastic changes. The nucleus became highly irregular in shape, as can be seen in Figure 4, and frequently multiple lobules developed. Although the cells continued to show considerable activity in the projected film, the individual lobules apparently retained their integrity for some time. The cytoplasmic connections between the lobules usually could not be seen, although the activity of the cells indicated that the lobules were bound together by cytoplasm.

The drastic changes in shape of the cell and nucleus were associated with changes within the nucleus. Gradually there developed in the degenerating nucleus one or more large, round, irregular vacuoles which were surrounded by a ring of dark material (cell C and D in Fig. 5). In lobulated cells, each lobule appeared to have

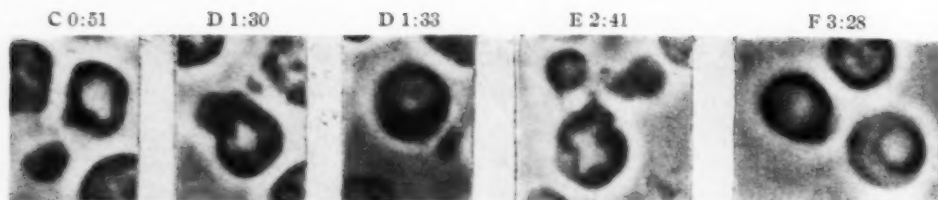


Fig. 5. Irradiated lymphocytes with large intranuclear vacuoles. A dark chromatin ring surrounds the vacuoles. Cells E and F are lobulated, with multiple vacuoles.

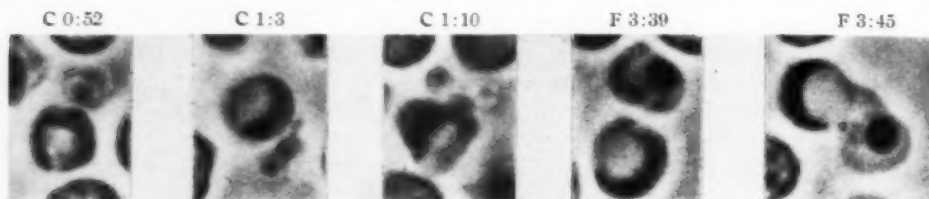


Fig. 6. Irradiated lymphocytes shortly after rupture of intranuclear vacuoles. The chromatin mass has the shape of a horseshoe or a crescent. Cell F has a small crescentic and a pyknotic chromatin mass.



Fig. 7. Irradiated lymphocytes with pyknotic, fragmented nuclei.

a separate small vacuole surrounded by a small dark ring (cell E and F). According to previous studies (5), the ring is composed of chromatin material and is Feulgen-positive. The degenerating cells with active lobulation and progressive vacuolation are considered viable, as they showed considerable vibratory activity and (in previous studies) resisted staining with eosin.

In the final stages of degeneration, the dark ring around the vacuoles apparently ruptured and the ring became horseshoe-shaped (cell C, Fig. 6). The chromatin material at this stage appeared to be semi-fluid and retracted with the formation of a crescent and semi-circle (cell C, Fig. 6) and finally to a dark round, structureless mass which was recognized as a pyknotic nucleus (cell C, Fig. 7). While the dark ring was converted to a pyknotic mass, the cell became less active in changing its

shape, the lobulations gradually retracted, and the cell became quiescent and round or slightly irregular in shape. In the lobulated cells with their multiple vacuoles and dark rings, multiple crescents and finally several small or large, dark pyknotic masses developed (cell F, Fig. 6). The end-result was a round cell with moderate cytoplasm and a pyknotic fragmented nucleus (Fig. 7).

The photographic procedures used in these experiments were not the best for measuring the duration of the degenerative process of lobulation and vacuolization. The onset of the rapid changes in shape of the cell could usually be fairly accurately determined. The end point was considered as the time of rupture of the intranuclear vacuole, with the formation of a dark, horseshoe-shaped chromatin mass. This stage was associated with the slowing down in the changes in shape of the cell and nucleus. It is believed that this end point corresponds to the death of the cell, with a change in its resistance to staining with eosin. The end point was not clearly defined in these films. The active degenerative process as defined above includes the changes shown in Figures 3, 4, and 5.

In the previous cinemicrographic study (1), the average duration of degeneration

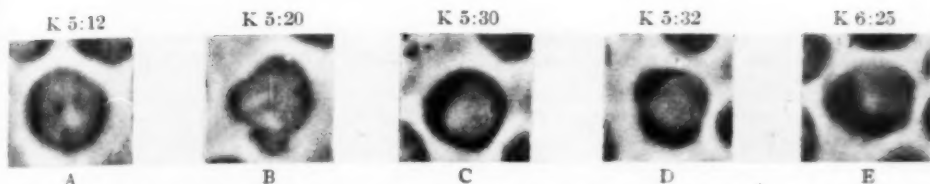


Fig. 8. Degenerative changes in a normal, non-irradiated lymphocyte. The photographs shown from left to right: A. A minute vacuole in the nucleus. B. An irregularly shaped nucleus. C. A large intranuclear vacuole surrounded by a dark, chromatin ring. D. A horseshoe-shaped chromatin mass. E. A dark crescentic nucleus.

was found to vary from ten to thirty-six minutes, with an average of twenty minutes. The present study with different apparatus and technic is more or less in accord with that estimate. For example, the degenerative stage in cell C lasted seventeen and in cell F nineteen minutes. It seems fairly definite that the duration of the process of lobulation and intranuclear vacuolization is relatively short.

In one preparation, 26 lymphocytes were observed in the photographic field at the beginning of incubation shortly after irradiation. With one exception, all the cells seemed viable, as indicated by the vibratory movement. Most of the 26 viable irradiated lymphocytes in the original field remained in the field and were photographed for about eight hours. The rate of formation of lobulated and pyknotic cells is shown in Table 1. The viable non-lobulated cells decreased rapidly from 96 to 17 per cent at eight and a half hours after irradiation. The number of vacuolated cells was never high at any one time, as would be expected in view of the short duration of the vacuolization.

Non-irradiated Lymphocytes: Similar studies were made with suspensions of non-irradiated cells. Due to limitations of equipment, the irradiated and the non-irradiated suspensions were not photographed on the same day and the cells were not derived from the same rabbit. The degenerative changes in one non-irradiated lymphocyte are presented in Figure 8. It is seen that in the untreated cell K a minute vacuole first developed. This cell also suffered a slight irregularity in shape and later showed a large vacuole with a chromatin ring. Ultimately the ring rup-

tured and the chromatin contracted into a crescent and finally into a round pyknotic nucleus (not shown in the figure). The degenerative changes in the non-irradiated lymphocyte were then similar or the same as in the irradiated cell.

In only a few cells was it possible to study the complete cycle of degeneration and death. The duration of the process of vacuolization was not determined with accuracy but was of the same order of magnitude in the untreated lymphocyte as in the irradiated cell.

The motion picture was analyzed to determine the survival of the untreated lymphocytes and the results are shown in Table 1. After eight hours of incubation, about 64 per cent of the normal lymphocytes remained viable while in the irradiated suspension 17 per cent of the cells survived eight and a half hours of incubation. The maximum number of pyknotic cells observed at one time in the untreated suspension was 10, eight hours after incubation; in the irradiated suspension incubated eight and a half hours, 20 pyknotic cells were seen. It is evident that x-rays stimulated the production of pyknotic cells.

Table 1 also shows that a few of the non-irradiated lymphocytes became lobulated and pyknotic early in the course of incubation. In fact, the first 6 cells started to lobulate in 18, 41, 70, 111, 129, and 178 minutes, or an average of 91 minutes. These results may be compared with the irradiated suspension, where lobulation started in the first 6 cells in 40, 80, 103, 110, 121, and 153 minutes, or an average of 102 minutes. In other words, the first few cells died as rapidly in the control as in the irradiated suspension. It would

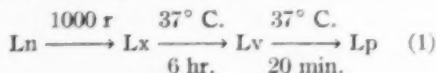
TABLE 1: NUMBER AND TYPES OF LYMPHOCYTES OBSERVED IN TIME-LAPSE CINEMOGRAPHIC FILMS OF AN IRRADIATED AND A NON-IRRADIATED SUSPENSION FROM RABBIT THYMUS

Hours of incubation	No. of Lymphocytes in Field	Percentage of Morphologically Normal Cells	No. of Degenerating Cells		
			Lobulated Cells	Pyknotic Cells	Fixed Cells
Irradiated suspension					
0.5	26	96	0	0	1
2.0	28	82	3	1	1
4.0	27	56	4	7	1
8.5	24	17	0	20	0
Non-irradiated suspension					
0	37	95	0	0	1
2	28	86	0	3	1
4	25	84	1	3	0
8	28	64	0	10	0

seem that the death of the first few cells after onset of incubation may be attributed to age and that there were an equal number of old cells in the control and experimental suspensions. These results, based on the observation of relatively few cells, do not exclude the possibility that x-radiation accelerated the death even of the first few cells.

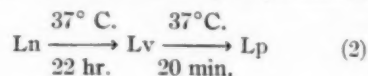
DISCUSSION

Equations Representing the Death of Lymphocytes: The present and the previous studies (3-8) on the death of irradiated lymphocytes may be summarized:



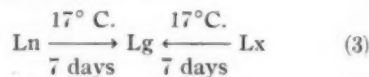
Irradiation of the normal lymphocyte *Ln* with 1,000 r yielded the physiologically altered lymphocyte *Lx*. Morphologically, cells *Ln* and *Lx* appeared identical. Incubation of *Lx* at 37° C. for about six hours yielded *Lv*, an irregularly shaped cell with one or more intranuclear vacuoles. According to time-lapse cinemicrography, *Lv* lasted about twenty minutes, yielding cell *Lp*, which was characterized by a crescentic or pyknotic nucleus.

The changes in non-irradiated, incubated suspensions are indicated by Equation 2.



During twenty-two hours of incubation at 37° C., vacuoles gradually developed in about half of the cells. The vacuolated cells, *Lv*, were morphologically similar to those obtained after irradiation with x-rays. The vacuolated cells in the incubated suspensions also terminated in the dead cells *Lp* with pyknotic nuclei.

The effects produced by incubation of cellular suspensions at 17° C. are summarized in Equation 3.



Cell *Ln*, or the irradiated cell *Lx*, when incubated at 17° C. for seven or more days, was converted to the dead cell *Lg*, the nucleus of which was not pyknotic but granular. Evidently irradiation and incubation or incubation alone at 37° C. yielded an end product, *Lp*, morphologically different from the end product *Lg* produced by incubation at 17° C.

Time-lapse cinemicrography and the method of unstained cell counts have proved to be particularly useful for developing the biologic equations and for studying the rates of reaction under various experimental conditions. The process *Lx* → *Lv* occurred only under more or less physiologic conditions and was inhibited by incubation at 17° C., by a pH of 6.0, and by anaerobiosis. In contrast, *Ln* → *Lx* was not sensitive to environmental conditions, such as low temperature.

The Action of X-Rays on Cells: The radiosensitivity of lymphocytes and dividing cells led to the suggestion in a previous paper (1) that these cells have a common physiologic process. There are many clues as to what this reaction may be.

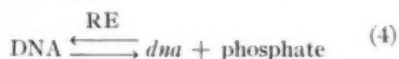
The nuclear changes in the degenerating lymphocytes as seen by phase and dark-field microscopy (4) suggest that normal desoxyribonucleic acid (DNA) became con-

verted to a degraded or depolymerized form (represented by *dna*). The intranuclear vacuoles indicate that a second product was formed in the degenerating lymphocyte. This substance, which collected in vacuoles, is considered to be a phosphate.

The assumed degenerative change of DNA to *dna* and phosphate is not enough, however, to explain the diverse cytologic findings. It seems necessary to assume that the catabolic reaction in the normal lymphocyte is reversible, *i.e.*, that *dna* takes up phosphate and synthesizes DNA. This assumption is in accord with the experimental observation that lymphoid tissue takes up radioactive phosphorus and synthesizes DNA (9, 10).

The synthesis of DNA from *dna* and phosphate is presumed to be controlled by an enzyme, labeled RE. Since phosphate is involved in the reaction, the synthesizing enzyme may be a phosphatase or an adenosinetriphosphatase. The occurrence and the significance of these enzymes in nuclei have been considered in various studies (11-15).

The common physiologic reaction assumed to occur in lymphocytes and dividing cells is then a reversible anabolic-catabolic reaction:



Irradiation is assumed to destroy the enzyme RE, thus inhibiting both the uptake of phosphate and the synthesis of DNA. A secondary result of the irradiation would be the accumulation of the depolymerized *dna* and of phosphate. The increase in phosphate would be expected to result in the influx of water and the enlargement of the nucleus.

The results of irradiation hypothesized above seem to be in accord with many experimental findings. Irradiation has been reported to cause the following phenomena: (a) the destruction of adenosinetriphosphatase (16) and of nucleolar alkaline phosphatase (17); (b) the inhibition of synthesis of DNA (9, 18, 19); (c) the de-

polymerization of DNA (20-22); (d) an increase in the size of the nucleus (20), which was considered by Failla (23) to be due to an influx of water. Thus the assumption of the reversible anabolic-catabolic reaction of Equation 4 accounts for the experimental observation that irradiation both accelerated depolymerization and decreased the synthesis of DNA.

The destruction of RE and the failure to synthesize DNA in focal areas as a result of irradiation may explain chromosome breaks in mitotic cells. The same focal destructive process may explain the observation that in hepatic and renal cells small intranuclear vacuoles developed which did not kill the radioresistant cells (24, 25).

The loss of RE as a result of irradiation is considered responsible for the death of lymphocytes and for the delay of mitosis in *Arbacia* eggs (26) and in corneal epithelial cells (27). The amount of persisting RE in the irradiated cell may determine the length of survival of the lymphocyte. The enzyme RE, and therefore the duration of survival, in a group of irradiated lymphocytes may be expected to vary as a normal logarithmic frequency distribution. This deduction is in accord with the previous experimental finding (2) that survival curves of normal and irradiated lymphocytes were linear on logarithmic probability paper.

The death of irradiated animals may also depend on the loss of the enzyme RE and the failure to synthesize some essential DNA. The survival of irradiated mice by spleen shielding (28) or by injection of bone marrow (29) would then be due to the ability of the spleen or marrow to provide the enzyme RE or an essential DNA to the irradiated animal.

The protective value of cysteine to irradiated animals and lymphocytes *in vitro* (30) may be attributed to a reversible chemical combination of cysteine with the enzyme RE. This reversible combination would remove some of the RE from the destructive action of x-rays. The chemical combination would be decreased or inhibited by low temperature. This

hypothesis would explain the surprising finding (31) that roentgen rays produced their primary action even at low temperatures but the protective action of cysteine occurred only at a higher temperature.

Incubation at a low temperature (4–17° C.) also inhibited the effect of irradiation on lymphocytes (3), salamander oöcytes (32), grasshopper embryos (33), frogs (34), and tadpoles (35). In these cases, the enzyme RE was presumably destroyed by the irradiation. The cells and animals at low temperature do not, however, synthesize DNA and do not presumably depend for their survival on the amount of RE. When the irradiated frogs were returned to a higher temperature, they again needed RE and they died from lack of it.

SUMMARY

A suspension from the rabbit thymus was irradiated (1,000 r), incubated at 37° C., and photographed with time-lapse cinematography. After a short latent period, there developed in the irradiated lymphocyte one or more minute intranuclear vacuoles. Suddenly the cell and its nucleus began to change rapidly in shape. The cell became highly irregular and lobulated and the nucleus showed one or more large vacuoles surrounded by dark rings of chromatin. Finally the vacuole or vacuoles ruptured, with the formation of horseshoe-shaped, crescentic, and hemispherical chromatin masses and the development of a pyknotic, fragmented nucleus. Non-irradiated lymphocytes suffered the same degenerative changes, although the onset of degeneration was greatly delayed. The duration of degeneration (from the onset of change in cellular shape to the rupture of the intranuclear vacuole) was approximately the same (twenty minutes) in both the irradiated and the non-irradiated cell.

The hypothesis is proposed that radiosensitive cells (lymphocytes and cells in mitotic division) have a specific reversible anabolic-catabolic reaction of deoxyribonucleic acid (DNA). The synthesis is controlled by an enzyme RE, which is radiosensitive. Destruction of RE by

irradiation inhibits synthesis and results in the progressive degradation of DNA. Protection against radiation depends on (a) inhibition of inactivation of RE (by cysteine), (b) inhibition of the degradation-synthesis reaction of DNA (by low temperature), or (c) replacement of RE (by spleen shielding). There is some indication that RE is an adenosinetriphosphatase or other phosphatase in the nucleus.

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SUMARIO

Observaciones Cinemicrográficas y Consideraciones Teóricas sobre Reacciones de los Linfocitos a los Rayos X

Una suspensión de timo de conejo fué irradiada (1,000 r), incubada a 30° C. y fotografiada con cinemicrografía de ritmo retardado. Al cabo de un breve período latente, se formaron en el linfocito irradiado una o más minúsculas vacuolas intranucleares. De repente, la célula y su núcleo comenzaron a cambiar rápidamente de forma. El glóbulo se volvió sumamente irregular y lobulado y el núcleo mostraba una o más vacuolas grandes rodeadas de anillos de cromatina. Por fin, reventaron la vacuola o vacuolas, formándose masas hipocrepiformes, semilunares y hemisféricas de cromatina y apareciendo un núcleo picnótico, fragmentado. Los linfocitos no irradiados experimentaron las mismas alteraciones degenerativas, aunque se demoró mucho la iniciación de la degeneración. La duración de la degeneración fué aproximadamente idéntica (veinte minutos).

fué aproximadamente idéntica (veinte minutos).

Ofrécese la hipótesis de que las células radiosensibles (linfocitos y células en vías de carioquinesis) tienen una reacción anacatabólica reversible específica de ácido desoxirribonucleico (ADN). Gobierna la síntesis una encima, RE, que es radiosensible. La destrucción de RE por la irradiación inhibe la síntesis y da por resultado la degradación progresiva del ADN. La protección contra la radiación se base en: (a) la inhibición de la inactivación de RE (por la cisteína), (b) la inhibición de la reacción de síntesis-degradación del ADN (por una temperatura baja), o (c) la substitución de RE (por el resguardo del bazo). Existe alguna indicación de que RE es una adenosinetri-fosfatasa u otra fosfatasa del núcleo.

X-Ray Attenuation in Lead, Aluminum, and Concrete in the Range 275 to 525 Kilovolts¹

WILLIAM MILLER² and R. J. KENNEDY³

A GREAT DEAL OF work has been done in recent years to determine how the attenuation of an x-ray beam is modified by the contribution of radiation scattered in the absorber. This scattering contribution depends on the irradiated area and on the solid angle subtended by the detec-

anism, the attenuation per unit thickness under broad-beam conditions is less than with a narrow beam. This increase in penetration is due to the fact that the Compton effect is a scattering process (with some energy degradation) rather than a total absorption process and some of the

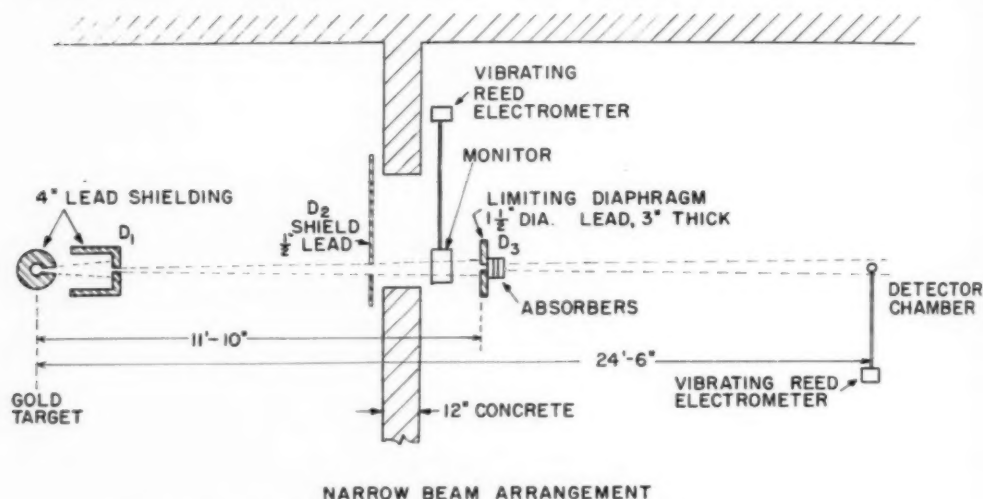


Fig. 1. Plan view of experimental set-up for narrow-beam attenuation measurement.

tor at the absorbers. The limiting case of a small irradiated area and a small detector solid angle is referred to as "good" or "narrow-beam" geometry; "poor" or "broad-beam" geometry implies that the irradiated area or the detector solid angle is large. In protection studies the term "broad beam" is slightly more restrictive, being used when both the irradiated area and the detector solid angle are large enough so that any further increase in either would not affect the attenuation. It has been found that when the Compton effect contributes to the absorption mech-

scattered photons ultimately penetrate the barrier. The ratio of penetrations under broad- and narrow-beam geometries, for a given thickness of absorber, is known as the build-up factor. In protection work, the attenuations are usually expressed in terms of percentage of dose transmitted, and the build-up determined with such data is known as the dose build-up factor. In general, the build-up factor increases with depth of absorber and with decreasing atomic number of absorber, but is not a simple function of the energy of the incident photons.

¹ From the National Bureau of Standards. This work was supported by the Atomic Energy Commission. Accepted for publication in November 1954.

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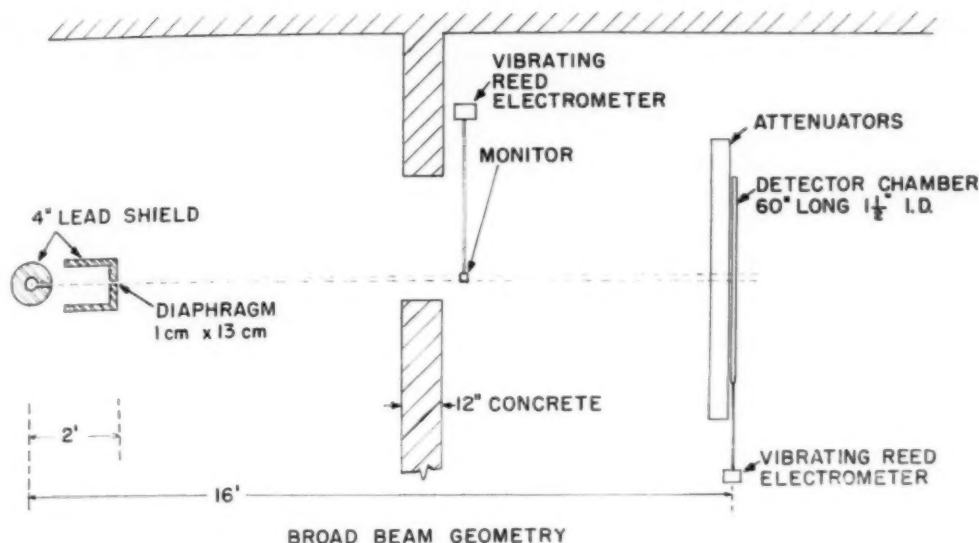


Fig. 2. Plan view of experimental set-up for broad-beam attenuation measurement.

In shielding against x-rays from machines with peak voltages below 250 kv, lead has been widely used because of its large photoelectric absorption coefficient. (The photoelectric absorption coefficient, in cm^2/atom , varies approximately as the fifth power of the atomic number.) Since photoelectric absorption accounts for almost all the attenuation in lead at these energies, the effect of build-up is negligible. For this reason, the narrow-beam data available for lead in this energy range (1) are sufficient for protection design.

At higher energies, a larger fraction of the attenuation mechanism consists of Compton scattering, which essentially involves interaction with electrons. Attenuation by this process depends, therefore, for all practical purposes, on the weight of the absorber per unit area. Thus, for protection against x-rays from machines operating at 500 kv to several million volts, lead loses most of its advantage, and concrete, having better structural properties, is commonly used. In designing a concrete shield, it is important to take account of build-up in the shield if it is to be exposed to a broad beam of radiation. Attenuation data in this energy range have recently been obtained (2) for lead and

concrete and for both "good" and "bad" geometry.

The tendency to increase the operating potentials of many types of machines from 250 kv toward 300 kv and the use of 400-kv machines has emphasized the need for attenuation data in the 250- to 500-kv region. Despite the fact that the build-up is significant at these energies, especially in concrete, there has been no systematic investigation of attenuation under broad-beam conditions in either lead or concrete. Most of the measurements which have been reported (3, 4) deal with narrow-beam attenuation studies in lead under varying conditions of filtration and voltage waveform. The results presented here are intended to provide a complete set of narrow- and broad-beam attenuation curves for lead and concrete, with fixed filtration, at 4 d.c. operating potentials in this voltage range.

EXPERIMENTAL SET-UP

The high-voltage generator used in these measurements has been previously described (5). The x-ray tube is a 59 section accelerator approximately 70 in. high, with a target extension chamber 15 in. long. Six hundred 10-megohm resistors are ar-

ranged in a helix about the tube and act as a potential divider for the accelerator sections. A gold reflection target is mounted at the end of the extension chamber and is so tilted that the electron beam has an angle of incidence of 45° .

Figure 1 is a plan view of the layout used in the narrow-beam attenuation measurement. The beam was collimated by the lead diaphragms D_1 , D_2 , and D_3 so that the irradiated area of the absorbers presented a small solid angle both to the

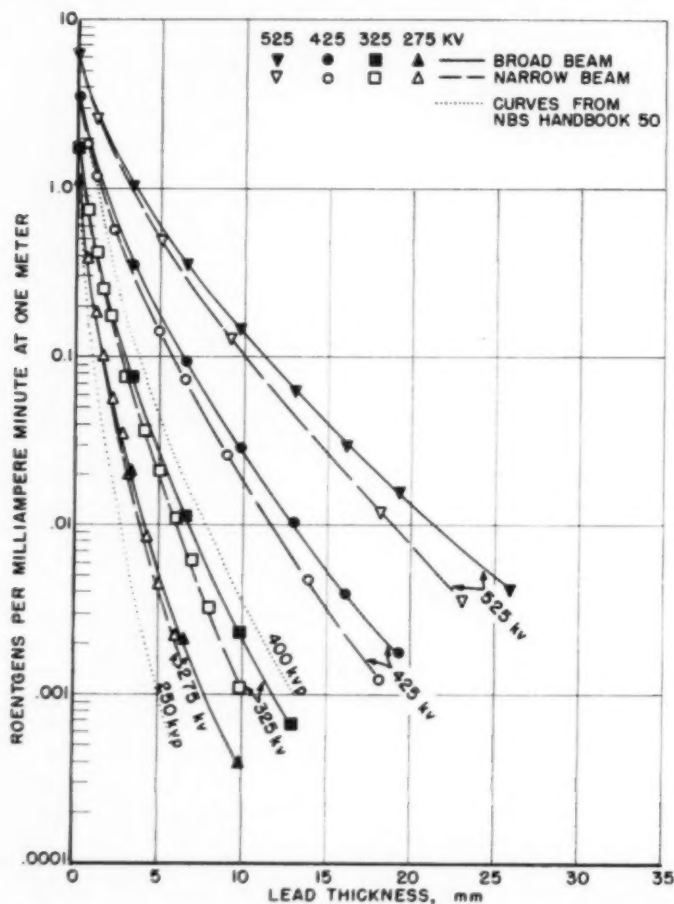


Fig. 3. Broad- and narrow-beam attenuation curves for lead. The 250- and 400-kvp curves have been reproduced from NBS Handbook 50. (The abscissas of the 250- and 400-kvp curves have been shifted to account for a difference in filtration.)

The focal spot has a diameter of 1.5 cm. and the inherent filtration consists of 1.5 mm. of copper, 1.5 mm. of brass, and 3.0 mm. of water. The primary shielding around the target is made up of 1.5 in. of lead and 3 in. of lead shot. The exposure time is controlled by a 3-in.-thick lead shutter system.

target and detector. The detector subtended an angle of less than one-half of a degree at the absorber, and since less than 1 per cent of the Compton scattered energy is scattered within one-half of a degree (for incident photons in the energy range of interest here), the error in absorption coefficient caused by the finite size of the

detector is small enough to be neglected.

The aluminum and lead absorbers were blocks 6-in. square and 0.5 to 25-mm. thick. The aluminum was a commercial grade, 2 S, and the lead was chemically pure. The concrete blocks measured $6 \times 8 \times 12$ in. and $4 \times 8 \times 12$ in., and had a specific

Figure 2 is a plan view of the experimental arrangement used in the broad-beam attenuation measurement. Because of space limitations, it was not feasible to use an x-ray beam 100 cm. in diameter to get the maximum broad-beam effect. It was possible, however, to obtain the

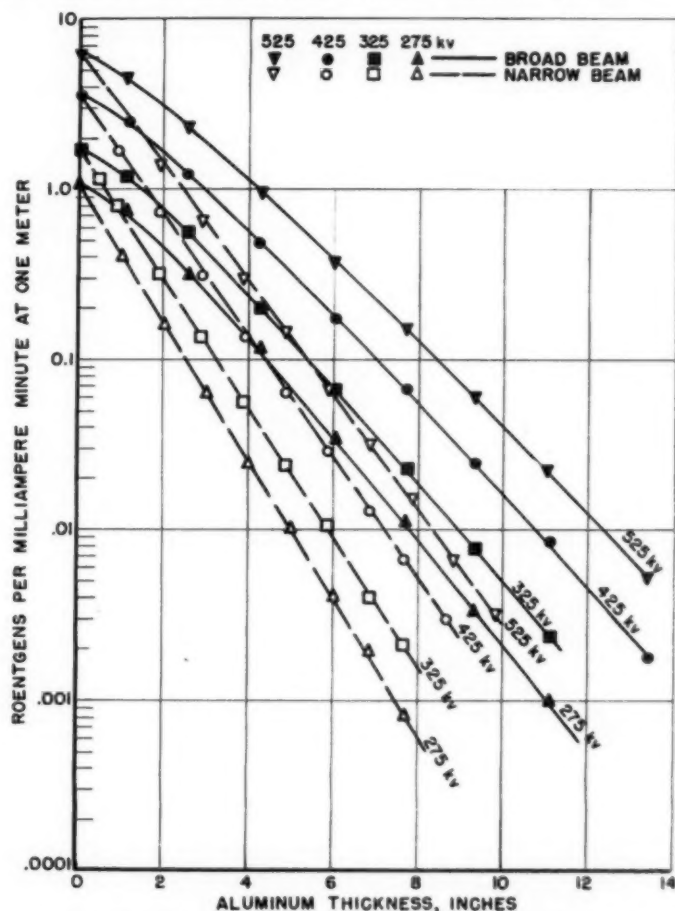


Fig. 4. Broad- and narrow-beam attenuation curves for aluminum.

gravity of 2.31. The thickness of the narrow-beam absorbers was measured to an accuracy of better than 1 per cent.

The detector used in the narrow-beam measurement was a 1/16-in. Bakelite-walled chamber with a collecting volume of 100 c.c. The x-ray beam was continuously monitored by a drum-head type transmission chamber with walls of 0.66 mm. of Al placed between D_2 and D_3 .

equivalent of a broad incident beam and a small detector by use of a sheet of incident radiation and a long tubular detector (5) with its axis perpendicular to the plane of the sheet. To obtain this sheet of radiation, the beam from the x-ray set was collimated by a lead shield with a slit opening measuring 1×13 cm., giving an irradiated area measuring about 8×100 cm. on the front face of the aluminum

attenuators. For the lead attenuators, the slit height was reduced until the irradiated region of the attenuator was only 70 cm. high (because of size limitations on the lead sheets). Earlier work (2) has indicated that this irradiated area is more

accuracy of 3 per cent. The detector was a Bakelite tube 60 in. long, 1.5 in. in diameter, with a wall thickness of 1/8 in. and a dag-coated aluminum wire of 0.03 in. diameter as the collector electrode. The monitor was the 100-c.c. Bakelite-walled

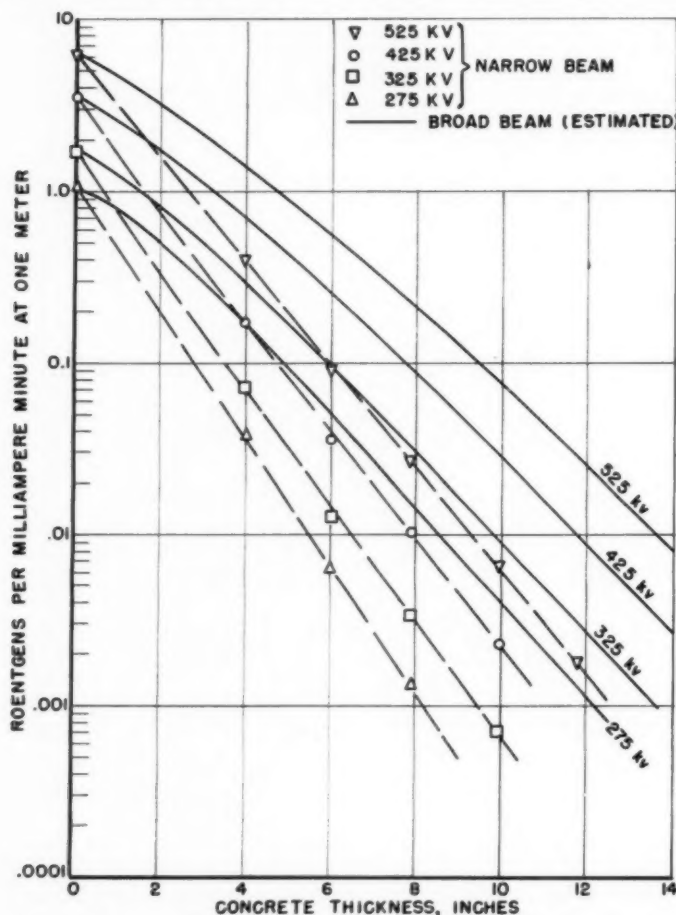


Fig. 5. Broad- and narrow-beam attenuation curves for concrete. The broad-beam curves have been estimated by applying the build-up factors obtained for aluminum to the narrow-beam curves in concrete.

than enough to give the full broad-beam effect in lead.

The absorbers in the broad-beam measurement were 2 S aluminum sheets, 4 × 6 ft., in nominal thicknesses of 3/16 and 1/4 in., and lead sheets 2 × 4 ft., 1/8 and 1/4 in. thick. The sheets of aluminum and lead were weighed and the area measured to determine the average thicknesses to an

chamber used as the detector in the narrow-beam measurement, but here placed across the bottom of the incident sheet of radiation.

The charge collected by the detector (and by the monitor) was measured by a voltage-compensation method, with a vibrating-reed electrometer as a null indicator.

RESULTS

Figure 3 contains the attenuation curves obtained in broad- and narrow-beam geometry for lead. The curves show a good deal of concavity, which indicates that the effective hardness of the beam, and hence the spectrum, is changing rapidly with depth. This is consistent with the rapid change of photoelectric absorption coefficient with energy. For the energies used here, the build-up factor in lead at ten half-value layers varies from about 1.5 at 275 kv to about 3 at 525 kv.

The 250-kvp and 400-kvp curves from *NBS Handbook 50* (1) are included in the figure for comparison. The abscissa of the 250-kvp curve has been shifted to account for the difference in inherent filtration. The 400-kvp curve seems to provide an underestimate of the x-ray penetration, when compared to the 325- and 425-kv broad-beam curves. This difference might be due, in part, to a difference in voltage wave-form and perhaps to lack of broad-beam geometry in the 400-kvp case.

The attenuation curves in aluminum (Fig. 4) follow a simple exponential almost exactly, and reflect the fact that the Compton process, with its relatively slow variation with energy, is the predominant absorption mechanism in this energy range. As was to be expected, the build-up factors for aluminum are much greater than those for lead, e.g., approximately 7 to 15 at ten half-value layers, depending on the energy.

The measured narrow-beam attenuation curves for concrete are shown in Figure 5. For these curves the thicknesses of con-

crete have been adjusted to correspond to 2.35 gm./c.c. Here, too, the Compton process predominates, and the attenuation curves are very closely simple exponentials. Since the Compton process involves interaction with electrons, it might be expected that the aluminum and concrete narrow-beam attenuation curves would coincide when the depth is expressed in electrons per square centimeter. The narrow-beam curves of Figures 4 and 5 do agree to within a few per cent when plotted in this manner. The broad-beam curves of Figure 5 have been obtained by applying the build-up factors of Figure 4 to the narrow-beam curves in Figure 5. This estimate should be quite reliable because the effective *Z* value for conventional concrete is so close to that of aluminum.

NOTE: We would like to thank Dr. H. O. Wyckoff for several helpful discussions.

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SUMARIO

Atenuación de los Rayos X en la Escala de 275 a 525 Kilovoltios en Plomo, Aluminio y Hormigón

Se ha medido la atenuación de los haces anchos y estrechos de rayos X aproximadamente a diez capas de hemirreducción en plomo y aluminio, para potenciales funcionales de rayos X (CD) de 275, 325, 425 y 525 kv. Los datos para haces estrechos también se obtuvieron para hormigón.

Los cálculos de la atenuación de haces anchos en hormigón se hicieron utilizando los correspondientes a haces estrechos en hormigón, obteniéndose el factor de incremento en aluminio.

En las Figuras 3-5 se reproducen las curvas.

Intravenous Cholecystangiography¹

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THE RECENT discovery of a chemical compound, Cholografin, has made it possible to demonstrate the bile ducts roentgenographically even though the gallbladder is absent or abnormal. The greatest advantage of this new intravenous method is in studying the biliary tree of the patient who has had a cholecystectomy. It has also proved valuable in cases of gallbladder disease in which the ordinary Graham test has been unsuccessful. This paper, based upon the first 100 cases selected for examination with Cholografin in a hospital and private radiological office in one community, indicates the usefulness, advantages, and limitations of the new chemical.

SELECTION OF PATIENTS

Originally the limited supply of Cholografin² restricted its use to cholecystectomized patients, to those in whom nausea or vomiting precluded the employment of an oral medium, and to those in whom diagnosis by the routine oral method was equivocal. Later, as the material became more available, its use was extended to certain cases at the special request of the surgeon or internist. Forty of the group examined had undergone cholecystectomy and in 60 the gallbladder was present.

TECHNIC

A dose of 20 c.c. of the 20 per cent solution injected into the cubital vein was found sufficient for routine cholecystangiography. In obese patients and in cholecystectomized patients, however, twice that amount was employed. The manufacturer's instructions were followed closely in preparing the patient, testing for sensitivity, rate of injection, and timing the



Fig. 1. Rapid filling of bile ducts and gallbladder in a vomiting patient forty minutes after injection. Note uneven mixing of the medium and bile in the gallbladder. The delicate white line accentuating the gallbladder mucosa may be due to concentration of the medium.

radiographic exposures (1, 5, 7). Special views, such as the vertical, lateral recumbent, and oblique were utilized as indicated. The most rewarding results of an examination occurred when each radiograph was viewed as soon as possible after its development, in order that the technic could be adapted to the individual case.

The examination was not carried out when jaundice was present but was delayed until the icterus had nearly or completely subsided. European investigators had reported (4, 7, 8, 11) that in the presence of liver damage Cholografin was excreted mainly in the urine.

¹ Accepted for publication in February 1955.

² Supplied by Squibb Institute for Medical Research, U. S. A., and by Schering, A. G., West Germany.

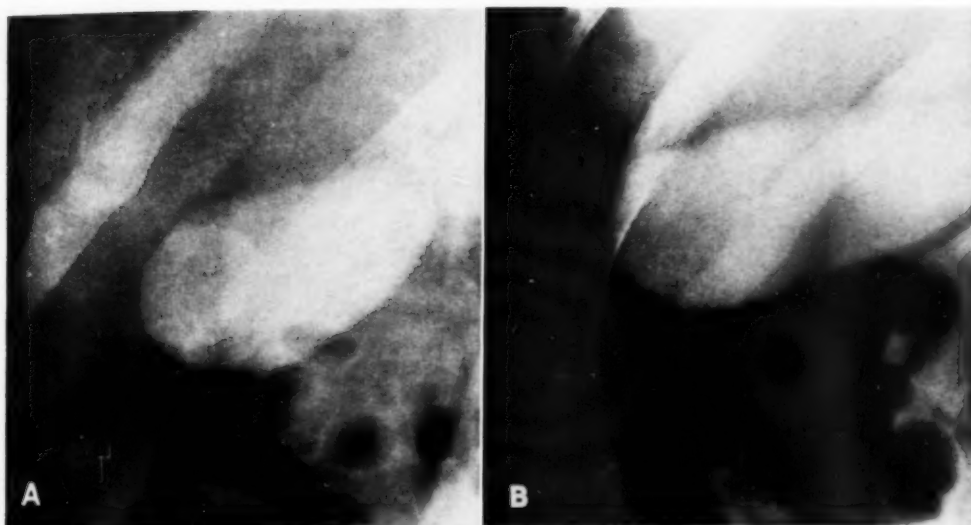


Fig. 2. A. Normal layering of bile simulating stone at sixty minutes. B. Concentrated and homogeneous bile in the gallbladder at one-hundred and twenty minutes.

RESULTS OF EXAMINATIONS

The findings in the 40 cholecystectomized patients were as follows:

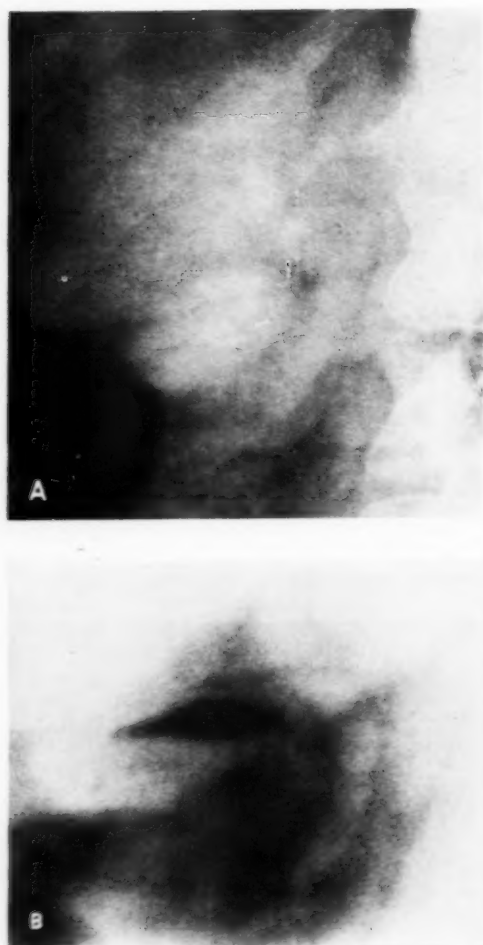
Normal bile ducts.....	26
Stones in common bile duct.....	4
Long cystic duct stump, other ducts dilated...	2
Cystic duct with "sac".....	4
Dilated ducts only.....	1
No visualization.....	2
No films taken.....	1

The symptoms in this group varied from mild indigestion to agonizing attacks of biliary colic. The interval between the performance of cholecystectomy and examination ranged from less than a year (in 5 patients) to twenty-five years. In 37 cases Cholografin outlined the biliary tree; in 26 of these the ducts were normal and in 11 some abnormality was found. The 4 cases of common duct stones were confirmed surgically (Fig. 6). Quite impressive were the cystic duct remnants, ranging from 3 to 5 cm. in length (Fig. 5); of even more interest was the sac formation at the end of the cystic duct (Fig. 3). A serious error of interpretation nearly occurred in one patient (Fig. 4), in whom reflux of Cholografin into the duodenal bulb simulated a gallbladder remnant.



Fig. 3. Biliary colic recurring six years after cholecystectomy. Note sac formation at end of cystic duct. Case confirmed surgically.

In the group of 60 patients with gallbladder disease (Table I), Cholografin outlined the bile ducts in 42 cases and the gallbladder in 31. It should be appreciated that in a high percentage of these cases determination of the status of the biliary tree by oral cholecystography was impossible, equivocal, unsatisfactory, or in need of con-



firmation. Excellent diagnostic visualization of the biliary tree was obtained in 11 patients whose persistent vomiting had made ingestion of an oral medium impossible (2 with acute surgical abdomens), and in 3 cases in which the gallbladder had been only faintly outlined with the oral medium.

In 10 patients with positive oral cholecystograms the intravenous method opacified the larger bile ducts in 7, while the cystic duct and gallbladder were seen in only 1. At operation the diagnoses for the 7 were cystic obstruction, cholecystitis, and cholelithiasis. One case diagnosed as a "palpable gallbladder" was believed to be pancreatic carcinoma until intravenous cholangiography demonstrated a normal common duct with non-filling of the cystic

Fig. 4. Cholecystectomized patient admitted with chills, fever, and epigastric pain. A. Intravenous cholangiography revealed slightly dilated bile ducts and an oval-shaped collection of contrast material similar to the one in Fig. 3. B. Fluid level in the erect position. C. Barium given orally proved that the collection is not in gallbladder remnant, but in the duodenal cap.

TABLE I: RESULTS OF EXAMINATION IN 60 PATIENTS WITH GALLBLADDER DISEASE

Indications for Intravenous Method	No. of Cases	Structures Visualized				Surgical Confirmation
		Hepatic and Common Bile Ducts	Cystic Duct and Gall-bladder	Stones in Gall-bladder	Stones in Ducts	
A. Oral method impossible (vomiting)	11	11	11	2	0	1
B. Oral method equivocal or unsatisfactory	4	4	4	1	0	1
C. Obvious biliary tract disease						
1. Non-visualization with Telepaque	10	7	1	0	0	7
2. Palpable gallbladder	1	1	0	0	0	1
3. Recent or subsiding jaundice	11	5	1	3	2	3
4. Failed cholecystostomy	3	0	0	0	0	3
D. Miscellaneous	20	14	14	5	0	0
TOTAL	60	42	31	11	2	16

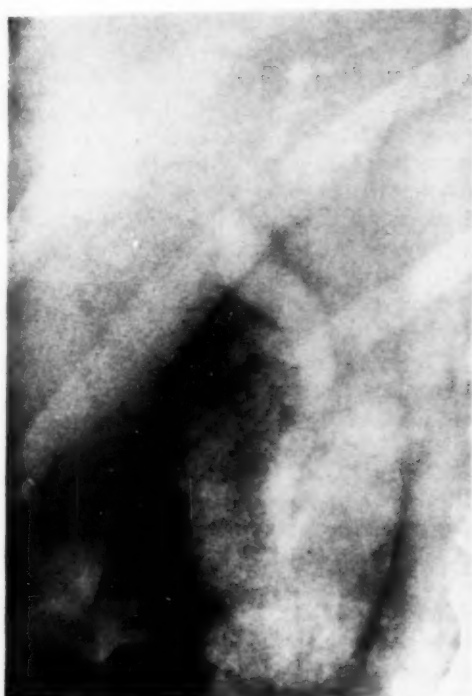


Fig. 5. Persistent biliary colic eighteen years after cholecystectomy. Note long cystic duct remnant, slightly dilated common bile duct, and reflux up pancreatic duct.

duct and gallbladder. Surgical exploration proved this to be another case of cystic duct obstruction with cholecystitis.

In 5 of 11 patients with recent or subsiding jaundice (an icteric index below 15 at the time of intravenous cholangiography), faint but satisfactory duct opacification resulted. Especially gratifying was a case of painless jaundice (Fig. 7) which had been diagnosed as infectious hepatitis. This patient would have been discharged without surgery had intravenous cholangiography not disclosed a common duct stone.

The 20 "miscellaneous" patients (Table I) were under observation or treatment in the hospital for a variety of conditions. Eight were solicited from the medical department for purposes of studying the new chemical. Suspicious pressure defects on the duodenum during barium studies called for the examination in 2 patients.



Fig. 6. Non-opaque stones in dilated common bile duct visualized with Cholografin three years after cholecystectomy. Case confirmed surgically.



Fig. 7. Painless jaundice for six weeks slowly subsided, after which this intravenous cholangiogram revealed a non-opaque stone partially obstructing the common duct.

In another instance, intravenous cholangiography was done to accommodate the physician and to save the patient time in the hospital, because through error oral

administration of the medium had been omitted the night before. In still another case there was reasonable doubt that the patient had actually ingested the oral preparation. In no instance in this particular group could it be proved that the cholecystangiograms were superior diagnostically to roentgenograms obtained by the oral method. Moreover, certain disadvantages of the intravenous method became acutely obvious in these routine gallbladder studies: its basic cost was higher than that of the oral method; it involved the inconveniences and potential hazards of intravenous methods in general; it was the most time-consuming examination done in the department; the layering phenomenon within the gallbladder (Figs. 1 and 2) was conducive to errors in diagnosis.

In only 19 of a total of 100 examinations was the concentration of Cholografin in the ducts judged inadequate for diagnosis. Failure in 12 of these cases was caused by cirrhosis or insufficiency of the liver associated with jaundice. Other technical difficulties, such as inability to dodge gas shadows, could be blamed for failure in 5 cases. In these it was believed that better visualization might have resulted if a double dose of the medium had been employed.

TOXICITY OF CHOLOGRAFIN

Symptoms due to Cholografin injection in this series were as follows:

No reaction.....	71
Nausea only.....	10
Nausea and vomiting.....	10
Metallic taste in mouth.....	9
Arm pain (at site of injection).....	4
Collapse.....	2
Diarrhea.....	0
Griping.....	0
Dysuria.....	0
Urticaria.....	0

In 71 of the 100 patients no untoward reaction of any kind was experienced. Noteworthy, too, was the low incidence of nausea and vomiting, and the absence of diarrhea, griping, and dysuria which sometimes occur with oral media. The duration

of symptoms was brief. No consistent changes in blood pressure, pulse, or respiratory rate were detected.

Thirty-eight patients had *urinalysis* immediately before and within forty-eight hours after Cholografin injection. Thirty-five showed no albumin in either sample,³ 1 showed a trace after injection, and 2 with a trace before injection had a 2+ reaction afterward.

The *cephalin flocculation* reaction was positive prior to Cholografin injection in 29 out of 36 patients. No correlation between the degree of positivity of this test and the degree of opacification of the biliary tree with Cholografin could be established. This was to be expected, since the cephalin flocculation test is not primarily a liver function test. Its object was to see what effect Cholografin would have on a sensitive qualitative indicator of liver damage. Unfortunately the project was not adequate; only 13 patients were given the test forty-eight hours after injection of the medium. In 3 the degree of flocculation decreased, in 4 others it was unchanged, and in 6 it increased slightly. Subsequent tests showed that this increase was a transient phenomenon.

In only 2 patients were there severe *shock reactions*. In spite of negative conjunctival and intravenous tests with the medium, both went into collapse within ten minutes after injection. These 2 cases are presented briefly because they illustrate the risks involved with any intravenous material and stress the importance of being equipped to handle the emergency as it arises.

M. K., a 71-year-old white female, complained of gaseous discomfort after eating, weakness, anorexia, and yellowing of the skin for three weeks. Physical examination and laboratory findings were essentially negative. Ten minutes after injection of 40 c.c. of Cholografin the patient went into a state of shock, characterized by an ashen-gray color and unconsciousness. Her pulse was absent, and blood pressure unobtainable. While responding to adrenalin, she complained of severe precordial pain boring through to her back. Recovery was rapid, and she was discharged on the fourth hospital day.

³ Heller's nitric acid ring test for albumin.

R. G., an obese, chronically ill female, had been hospitalized over fifteen times since 1936, chiefly because of attacks of right upper quadrant and precordial pain radiating to the shoulders and back. Electrocardiographic examinations were diagnostic of myocardial infarction. Since the usual veins for injection were hidden by obesity, Cholografin was introduced into the left femoral vein. During injection the patient became unconscious, pulseless and cyanotic, and the blood pressure could not be determined. After subcutaneous administration of Demerol and adrenalin she rallied, but was unable to co-operate for radiography. She was discharged from the hospital several days later, with no ill effects.

A shock reaction is always alarming, and every possible means of prevention and precautionary measures for therapy should be carried out. Vasomotor collapse may occur with any intravenous injection, particularly of products used for contrast radiography, and this possibility should not necessarily prejudice against the use of a valuable diagnostic method, if the reaction incidence is low and the risks are appreciated and prepared for. The value of the information to be obtained should be weighed against the potential hazard of the method used to secure it.

DISCUSSION

Clinical studies with Cholografin have altered the radiologist's attitude toward intravenous cholecystangiography as a diagnostic procedure. During the thirty years since Graham and Cole introduced cholecystography, the popularity of the intravenous method gradually waned, not only because of serious reactions associated with its use but also because of the time consumed and the cumbersome details involved. In the meantime, the oral method attained a high degree of diagnostic accuracy. Radiographic equipment was developed and improved, technical methods were refined, and radiologists gained experience in interpretation of the roentgenograms. Dohrn and Dietrich's development of a relatively non-toxic contrast medium, iodoalphonic acid, and the appearance on the market of other similarly improved products, have established the oral method as the choice for

routine cholecystography (5). Shehadi's fatty meal technic (6, 12) portrays the ducts in such a high percentage of cases that the need for intravenous cholangiography is obviated in patients with normally functioning gallbladders. The non-visualized gallbladder, however, may still pose a diagnostic problem, and it is here that intravenous cholangiography supplies valuable data.

When non-absorption of an orally administered medium results in non-visualization of the gallbladder, Cholografin usually delineates the biliary tree promptly and accurately, and often is a means of reducing hospital days. When, because of obesity, faint concentration of the medium, or superimposed gas shadows, the oral cholecystogram is equivocal, Cholografin may reveal a filling defect more clearly by increased opacification of the biliary tree. In this series, visualization of the bile ducts with Cholografin and non-filling of the gallbladder were pathognomonic of gallbladder disease.

When emergency or expediency demands that intravenous cholecystography be employed, it must be remembered that good filling of the bile ducts and gallbladder does not necessarily exclude cholecystitis, since a patent cystic duct may allow Cholografin to fill the lumen of a diseased, non-functioning organ. Since it is not always possible (Fig. 1) to differentiate mere accumulation from actual concentration of Cholografin within the gallbladder, oral cholecystography is preferred as the test for gallbladder function.

The outstanding indication for intravenous cholangiography is the so-called post-cholecystectomy syndrome. Surgically curable conditions such as gallbladder remnants, abnormal cystic duct stumps, and duct stones now can be demonstrated roentgenologically. The small but significant incidence of such lesions in this series would seem to justify the routine performance of intravenous cholangiography in all patients who have undergone cholecystectomy but still continue to have symptoms of biliary disease.

SUMMARY AND CONCLUSIONS

A critical study of 100 examinations of the biliary tract with intravenous Cholografin was made. In over one-fourth of the patients with symptoms after cholecystectomy such conditions as stones in the ducts, dilated ducts, gallbladder remnants, and long cystic duct stumps were demonstrated. In cases where routine oral cholecystography was impossible, unsuccessful, or equivocal, the new intravenous method furnished valuable information about the biliary tree.

In view of the advantages and limitations of the new method, it would appear that oral administration will remain the proper choice for routine cholecystography.

Intravenous cholangiography is indicated in patients whose symptoms recur after cholecystectomy. It has great value, also, as a supplementary examination when the routine oral cholecystogram is unsuccessful or equivocal.

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SUMARIO

La Colecistangiografía Intravenosa

Este estudio analítico comprendió 100 exámenes del aparato biliar con la Colografía por vía endovenosa. Más de la cuarta parte de los enfermos que mostraban síntomas después de la colecistectomía resultaron tener lesiones tales como cálculos en los conductos, conductos dilatados, restos de la vesícula biliar y muñones largos del conducto cístico. En los casos en que el habitual colecistograma oral resultaba imposible, infructuoso o equí-

voco, la nueva técnica intravenosa reveló información valiosa acerca del árbol biliar.

La colangiografía intravenosa está indicada en los sujetos cuyos síntomas recurren después de la colecistectomía. Posee, además, mucho valor como examen complementario cuando el habitual colecistograma oral resulta infructuoso o equívoco. Sin embargo, parece que, en general, la administración oral seguirá siendo la más apropiada para la colecistografía corriente.

Ureteral Jet Phenomenon

Stream of Opaque Medium Simulating an Anomalous Configuration of the Ureter¹

EDMOND H. KALMON, M.D., DONALD D. ALBERS, M.D., and J. HARTWELL DUNN, M.D.

EXCRETORY UROGRAMS made in the course of routine urologic study of two girls with recurrent urinary tract infections showed an unusual configuration of the terminal left ureters. These ureters appeared to cross the mid-line and terminate in the region of the trigone on the opposite side of the bladder. Findings on subsequent cystoscopic examination and retrograde pyelography in each case were entirely normal.

We have not encountered any mention of this roentgenographic finding in the literature. Personal communication with other urologists and radiologists confirms the rarity of the observation.

CASE REPORTS

CASE I: A 5-year-old white girl had experienced several bouts of pyuria associated with high fever, which responded well to antibiotic therapy. The causative organism was usually a micrococcus (*Staphylococcus*), coagulase-positive. In December 1953, following a typical attack of urinary tract infection, an excretory urogram was obtained with 15 c.c. of 30 per cent Urokon. The left ureter showed what appeared to be an anomalous termination in the urinary bladder (Fig. 1). At cystoscopy the trigone appeared normal, the vesical neck was thought to be mildly obstructed, and there was minimal trabeculation of the bladder. Retrograde study revealed a normal left ureter (Fig. 3). This patient was treated conservatively with repeated urethral dilatations and intermittent chemotherapy.

CASE II: A girl of 3½ years had a history of recurrent urinary tract infections, with high fever complicated by generalized convulsive seizures. The infections were due to *E. coli*. In January 1953, the upper urinary tract was found to be normal on intravenous pyelography. Because of continuing infections the urinary tract was again examined in February 1954. An excretory urogram, obtained with 15 c.c. of 30 per cent Urokon, showed an anomalous terminal left ureter (Fig. 2) quite similar to that in Case I. On cystoscopy the trigone appeared normal, but there was mild trabeculation of the

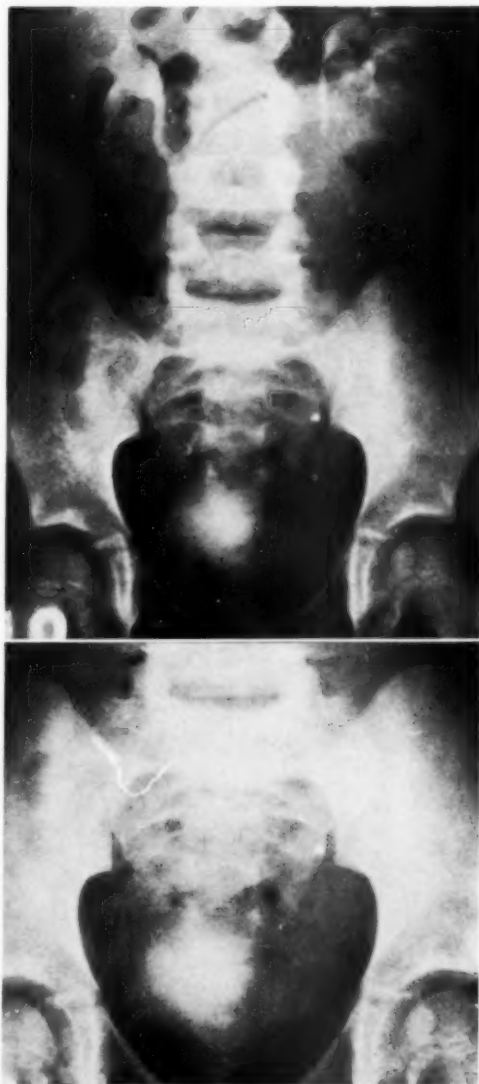


Fig. 1. Case I. An excretory urogram in which the terminal portion of the left ureter appears to extend across the mid-line to the opposite side of the trigone. Close-up view below. A retrograde urogram (Fig. 3) showed the ureter to be normal.

¹ From the Departments of Radiology and Urology, Wesley Hospital, Oklahoma City, Okla. Accepted for publication in November 1954.



Fig. 2. Case II. An excretory urogram in which the ureteral jet is seen extending across the urinary bladder as an apparent anomalous ureteral termination. Close-up view below.

bladder secondary to a vesical neck obstruction. A left retrograde pyelogram showed a normal terminal ureter (Fig. 3). This patient was treated by transurethral resection of the vesical neck.



Fig. 3. Retrograde studies of Cases I (left) and II (right), showing normal left ureters.

COMMENT

The unusual urographic finding in these two cases is thought to be the result of making the roentgenogram just as a bolus of contrast medium was being ejected from the ureteral orifice. This ureteral jet of highly concentrated radiopaque medium streamed across the trigone, giving the appearance of a prolonged ureter opening on the opposite side of the bladder. Subsequent cystoscopy and retrograde pyelography demonstrated a normal ureteral termination in each instance.

The age of these patients, the infections, and the vesical neck obstructions might be considered as possibly contributing to this unusual observation.

This ureteral jet urographic phenomenon is reported simply as a curiosity, in the realization that others will see and perhaps be puzzled by it.

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SUMARIO

El Fenómeno del Chorro Ureteral: Flujo de Medio Opaco Simulando Configuración Anómala del Uréter

Describe aquí un hallazgo urográfico extraño. En los urogramas excretorios, practicados en el estudio urográfico corriente de 2 niñas de cinco y tres y medio años de edad, respectivamente, con infecciones recurrentes del aparato urinario, la porción terminal de los uréteres izquierdos parecía cruzar la línea media y terminar en la región del triángulo en el lado opuesto de la vejiga. Los subsiguientes exámenes cistoscópicos y pielogramas retrógrados revelaron que eran normales.

Parece que el fenómeno provino de haberse tomado la radiografía precisa-

mente cuando se expulsaba por el orificio ureteral un bolo de medio de contraste radiopaco sumamente concentrado. Este manó a través del triángulo, creando la impresión de un uréter prolongado que desembocaba en el lado opuesto de la vejiga. La edad de las enfermas, las infecciones y las oclusiones del cuello vesical también pudieron desempeñar algún papel.

Este fenómeno urográfico del chorro ureteral se describe puramente como curiosidad, por creerse que otros lo observarán y se quedarán perplejos.



EDITORIAL

Roentgen Examination of the Liver

The long history of research into methods for the roentgen demonstration of the liver and its internal structures is a record of disappointments. Considering the five tubular structures and the two sets of cells, hepatic and reticuloendothelial, by which a contrast substance could be introduced into the liver, it is indeed surprising that more success has not attended such efforts. No doubt the great bulk of the liver and the lack of access to it from without have been in large part responsible for the unsatisfactory results. Attempts to find a harmless substance specifically excreted or secreted by the liver in sufficient quantities to make the internal anatomy of the organ visible in the roentgenogram have uniformly failed. That the size and shape of the liver can be demonstrated either by direct radiographic study or by pneumoperitoneum is evident, but such findings add little to our diagnostic ability.

When cholecystography was first introduced, it was hoped that sufficient amounts of the contrast substance would fill the bile canaliculi, before passage into the bile ducts, to produce a roentgenogram of the liver parenchyma. Although the gallbladder and, to a lesser degree, the external bile ducts, were visualized in this way, the intrahepatic ducts and the liver cells could not be seen. Then followed the demonstration that the biliary duct system could be made visible by injection during a laparotomy or afterward, through a surgically created external fistula. Various means were proposed to permit injection of the biliary ducts or gallbladder through the intact abdominal wall, either blindly or with the aid of the peritoneoscope. The recent development of intravenous cholangiography has solved,

to a partial degree at least, the problem of roentgenography of the biliary duct system. Altogether, x-ray study of the bile ducts can now be reasonably well accomplished.

The introduction into the blood stream of a stable colloidal substance, Thorotrast, which has a high opacity to roentgen rays and is absorbed by the reticuloendothelial cells of the liver, resulted in a brilliant demonstration of the size, shape, and position of the liver and of its internal structures (16, 17). By this means, tumors of the liver, cirrhosis, and various other diseases could be effectively portrayed. Unfortunately, this substance is slightly radioactive and, what is even more important, it remains almost permanently within the liver after its introduction. There is some evidence that it may be slightly carcinogenic. As a practical method for the roentgen study of this organ, it has therefore fallen into disuse.

Various other colloidal substances, with iodine as the opaque medium, were then prepared (2, 8). While some proved effective in producing contrast, none has been free from serious hazard and they are therefore rarely used. An excellent summary of such studies was presented by Gershon-Cohen and McClendon (12). More recently, with the same purpose in mind, Shapiro (20) has employed zirconium compounds but, so far, with little success.

In recent years, attempts at contrast study of the interior of the liver have been directed toward its vascular structures. Moore and Bridenbaugh (13, 14), as well as other workers, showed that injection of a branch of the portal vein through the opened abdominal wall would permit an effective contrast demonstra-

tion of the portal circulation, both intra- and extrahepatic. Furthermore, films made at a suitable period after injection revealed an opacification of the liver parenchyma itself, resulting from release of the contrast medium from the portal branches into the liver sinusoids. As a practical method of examination, however, this procedure has great limitations, largely because of the fact that the vessels must be injected during the course of a major surgical procedure, *i.e.*, laparotomy. Other efforts to accomplish portal venography by injection of superficial or distant veins in certain abnormal cases were pursued by Fariñas (11) and by Dotter and associates (10) but have not been of practical value. A number of investigators, most recently Tori and Scott (22), have succeeded in catheterizing the hepatic vein in animals, but the procedure has not been applied to human beings.

Bierman and his associates (5, 21) have shown that it is possible to accomplish portal venipuncture by a percutaneous, transhepatic approach. They were successful in demonstrating the portal circulation itself; if serial radiography had been undertaken, no doubt complete visualization of the parenchyma of the liver would also have been obtained. Again this represents a somewhat difficult approach because of the necessity for direct puncture of the liver parenchyma before entering the portal vein. The method has not attained clinical acceptance, although no ill results have been reported.

Rigler, Olfelt, and Krumbach (17, 18) indicated the possibility of visualization of the portal circulation, and of the liver parenchyma, through the use of abdominal aortography. The injection of large quantities of contrast medium with great rapidity into the aorta, well above the celiac axis, followed by serial angiograms, produced visualization of the entire substance of the liver as well as of the portal circulation. The contrast medium enters the liver both from the hepatic artery and from the return flow of the splenic and mesenteric veins into the por-

tal circulation. Here again repeated serial roentgenograms are required and the small hazard attendant upon abdominal aortography is present.

In 1951, Abeatici and Campi (1) described what is at present called splenoportography, *i.e.*, a direct percutaneous injection of the spleen itself. The contrast medium passes from the splenic pulp into the splenic vein and then into the portal circulation, which is adequately opacified. It is possible by this means also to visualize the parenchyma of the liver if serial roentgenograms are made at appropriate times after the introduction of the contrast medium. This method of investigation is being practiced widely abroad (6, 9) and to some degree in this country as well (7, 19). There is, however, a marked difference of opinion as to the safety of the procedure. European investigators feel that it carries a minimum degree of risk. My own experience, and that of a number of other American radiologists, has been that a serious risk is involved, particularly if the spleen is abnormal. Puncture of the peritoneum, tearing of the splenic capsule, and perisplenic hemorrhage have all been reported.

Bierman, Miller, Byron, Dod, Kelly, and Black (4) in 1948 demonstrated that the arteries of the liver could be injected directly through a catheter introduced into the innominate artery and passed down into the hepatic artery. X-ray study with contrast medium under these circumstances has permitted an effective investigation of the blood supply of tumors of the liver. Further studies by Bierman and his associates (3), using this method, have added greatly to our knowledge of both primary and metastatic tumors of the liver.

It is evident from this brief review that a really ideal method for the roentgen study of the liver has not yet been devised. All of the methods described above involve some hazards, some complications, and a complexity of performance which is not desirable in the clinical examination of patients. Nevertheless, the use of one

or another of these procedures may be extremely effective in special cases for the definitive determination of the presence of such diseases as cirrhosis, portal obstruction, primary and metastatic tumors, and abscesses. Certainly, the direct splenic puncture should be undertaken whenever surgery is contemplated for the relief of obstruction in the portal circulation at any point, for in this way the actual course of the portal circulation can best be determined, as has been so well demonstrated by Rousselot, Ruzicka, and Doehner (19) and others. The preparation of the patient for surgical exploration of the abdomen minimizes the risk of splenic puncture. Likewise, when it is important to determine the nature of disease processes within the liver, it can be accomplished in this way or by means of abdominal aortography. The method of percutaneous portal venipuncture, or catheterization of the liver through the hepatic artery, is most valuable for experimental studies under controlled conditions but probably requires too much experience, skill, and effort for widespread application.

The possibility of roentgen opacification of the liver through the use of some contrast substance attached to one of the excretory products of the liver, such as urea, has not been fully explored. A radio-paque, stable, colloidal suspension which will break down in time without toxic effects still remains to be discovered. The invention of such ideal methods must be the product of future research. Nevertheless, much has been accomplished during the past decade. The methods of x-ray study of the liver and its internal struc-

tures have been notably improved; the diagnostic contributions of the roentgen examination of the liver have been greatly enhanced.

LEO G. RIGLER, M.D.

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ANNOUNCEMENTS AND BOOK REVIEWS

OREGON RADIOLOGICAL SOCIETY

The following officers have been elected by the Oregon Radiological Society for the coming year: President, Gregory B. Nichols, M.D., Portland; President-Elect, James B. Haworth, M.D., Salem; Vice-President, J. W. Loomis, M.D., Portland; Secretary-Treasurer, N. L. Blin, M.D., 210 Jackson Tower, Portland 5; Executive Committee-man, Wayne G. Erickson, M.D., Portland. The nominee for Councilor to the American College of Radiology is G. B. Isenhardt, M.D., Portland, with Charles T. Dotter, M.D., Portland, as alternate.

MONTANA RADIOLOGICAL SOCIETY

At a recent meeting of the Montana Radiological Society the following new officers were elected: President, Grant P. Raitt, M.D., Billings; Vice-President, Richard Bridenbaugh, M.D., Billings; Secretary-Treasurer, John Stewart, M.D., The Billings Clinic, Billings.

WISCONSIN RADIOLOGICAL SOCIETY

At the annual meeting of the Wisconsin Radiological Society, held Oct. 7 and 8, 1955, the following officers were elected: President, Dr. Ralph Frank of Eau Claire; President-Elect, Dr. Lester Paul of Madison; Secretary-Treasurer, Dr. William W. Moir, Memorial Hospital, Sheboygan, Wisc.

GRADUATE PROGRAM IN BIOPHYSICS

A graduate program in Biophysics which leads to either the M.S. or Ph.D. degree has been established by the Sloan-Kettering Division of the Cornell University Medical College. The M.S. program is devoted specifically to Radiation Physics and includes training in clinical radiological physics, medical and research applications of radioisotopes, and health physics. Extensive facilities in the Sloan-Kettering Institute and Memorial Hospital are available for M.S. or Ph.D. thesis problems in various physical, chemical, or biological effects of different qualities of radiation. Related courses can also be scheduled at neighboring universities. A limited number of fellowships is available.

Additional information may be obtained by writing Dr. J. S. Laughlin, Department of Biophysics, 410 E. 68th St., New York 21, N. Y.

DAVID ANDERSON-BERRY MEDAL

A David Anderson-Berry silver-gilt medal, together with a sum of money amounting to about £100, will be awarded in 1956 by the Royal Society of Edinburgh to the person, who, in the opinion of the Council, has recently produced the best work

on the therapeutic effect of x-rays on human diseases. Applications for this prize, based on either published or unpublished work, accompanied by copies of the relevant papers, should be in the hands of the General Secretary, Royal Society of Edinburgh, 22 George St., Edinburgh 2, not later than March 31, 1956.

Books Received

Books received are acknowledged under this heading and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

CONSOLIDATED INDICES. VOLUME IV. Embracing the American Journal of Roentgenology and Radium Therapy, Volumes 59-68 (1948-1952). Compiled under the direction of the Publication Committee and the Editorial Office of the American Roentgen Ray Society. A volume of 486 pages. Published by Charles C Thomas, Springfield, Ill., 1955. Price \$13.50.

THE ATOMIC NUCLEUS. By ROBLEY D. EVANS, Ph.D., Professor of Physics, Massachusetts Institute of Technology. A volume of 972 pages, with numerous graphs and tables. Published by McGraw-Hill Book Co., Inc., New York, Toronto, and London, 1955. Price \$14.50.

RECENT ADVANCES IN RADIOLOGY: By THOMAS LODGE, M.B., Ch.B. (Sheff.), F.F.R., D.M.R., Consultant Radiologist, United Sheffield Hospitals and Sheffield Regional Hospital Board; Clinical Teacher in Radiodiagnosis, University of Sheffield; Hon. Editor, Journal of the Faculty of Radiologists. A volume of 358 pages, with 182 illustrations. Published by Little, Brown & Co., Boston, 3rd ed. 1955. Price \$10.50.

DOSAGE ESTIMATION IN RADIOTHERAPY AND THE WHEATLEY INTEGRATOR. Acta radiologica Supplement 128. By BOYCE WORTHLEY, JOHN TOOZE, JOAN BROWN, AND ROBERT M. FRY. A monograph of 170 pages, with numerous tables and graphs. Published by Acta radiologica, Stockholm, Sweden, 1955. Price Sw. Kr. 25:—

PRECANCEROUS CHANGES OF THE CERVICAL EPITHELIUM IN RELATION TO MANIFEST CERVICAL CARCINOMA. CLINICAL AND HISTOLOGICAL ASPECTS. Acta radiologica Supplement 127. By OLAF PETERSEN. A monograph of 168 pages, with photomicrographs, graphs, and tables. Published by Acta radiologica, Stockholm, Sweden, 1955. Price Sw. Kr. 25:—

LUNGENKREBS UND BRONCHOGRAPHIE MIT UNTERSUCHUNGEN ÜBER URSPRUNG UND URSPRUNGSBEDINGUNGEN DES BRONCHIALKARZINOMS. Fortschr. a. d. Geb d. Röntgenstrahlen, Ergänzungsband 75. By Dr. H. ANACKER, Dozent an der Justus-Liebig-Hochschule, Giessen. A volume of 78 pages, with roentgenograms, photographs, schematic drawings, and tables. Published by George Thieme Verlag, Stuttgart, 1955. Distributed in the United States and Canada by the Intercontinental Medical Book Corporation, New York, N. Y. Price DM 28.50 (\$6.80).

RADIO-ANATOMIE GÉNÉRALE DE LA TÊTE: 37 COUPES ANATOMIQUES DANS LES TROIS PLANS DE L'ESPACE, DESSINÉES, RADIOGRAPHIÉES ET COMMENTÉES. By ROBERT AUBANIAC, Agrégé d'Anatomie, and JACQUES POROT, Assistant d'Electro-Radiologie des Hôpitaux de Paris. Préface by Professeur R. M. de Ribet. One hundred and fifty-two pages, with 36 roentgenograms and 38 schematic drawings. Published by Masson & Cie, 120, Boulevard Saint-Germain, Paris, 1955. Price 5,000 fr.

ANATOMIE RADIOGRAPHIQUE DU MASSIF FACIAL. SCHEMAS RADIOGRAPHIQUES DES PRINCIPALES INCIDENCES. By MAURICE BOUCHET, Oto-Rhino-Laryngologiste des Hôpitaux de Paris, and GEORGES DULAC, Electro-Radiologiste, Ancien Chef de Service de la Fondation Curie, with the collaboration of RENÉ PAILLER, Membre correspondant de la Société de Laryngologie des Hôpitaux de Paris. A volume of 188 pages, with 103 illustrations. Published by Masson & Cie, 120, Boulevard Saint-Germain, Paris, 1955. Price, Broche 2,800 fr; Cartonné toile 3,600 fr.

Book Reviews

ATLAS OF ROENTGEN ANATOMY OF THE SKULL. By LEWIS E. ETTER, B.S., F.A.C.R. Assistant Professor of Radiology, School of Medicine, University of Pittsburgh; Roentgenologist, Western Psychiatric Institute and Clinics. With a Section on The Radiographic Anatomy of the Temporal Bone by J. BROWN FARRIOR, M.D., F.A.C.S., Farrior Clinic, Tampa, Florida, and a Section on The Roentgen Anatomy of the Skull in the Newborn Infant by SAMUEL G. HENDERSON, M.D., F.A.C.R., Associate Professor of Radiology, and LOUISE S. SHERMAN, B.S., M.D., Instructor in Radiology, School of Medicine, University of Pittsburgh. A volume of 216 pages, with 239 illustrations and 7 tables. Published by Charles C Thomas, Springfield, Ill., 1955. Price \$14.75.

This roentgenographic atlas represents a new approach to the study of the anatomy of the cranium. The author has disarticulated the bones of the skull and has photographed and radiographed them in the

standard positions used in clinical roentgenography. He has also taken radiographs of the skull from which individual bones have been removed, facilitating the identification of certain lines and shadows.

Chapters are devoted to the skull as a whole, the paranasal sinuses and mastoids, temporal bone and petrous mastoid portions, the orbits and optic foramina, and the maxillo-facial components. The excellent illustrations are fully labeled with legends which identify the anatomical landmarks. Four are in color. A separate chapter on the roentgen anatomy of the skull in the newborn by Samuel Henderson and Louise S. Sherman is a valuable addition.

An adequate index of the anatomical landmarks completes the volume, which should prove valuable for radiologists, surgeons, and all those whose work includes study of the skull.

In Memoriam

AUBREY O. HAMPTON, M.D.

1900-1955

On July 17, 1955, one of America's great radiologists, Dr. Aubrey O. Hampton, died of a cerebrovascular accident at his farm in Weare, N. H. Dr. Hampton was beloved as a man and admired as a radiologist and his death at the age of 54 is mourned by a host of friends.

Dr. Hampton was born in Copeville, Texas, received his medical degree at Baylor University Medical School in 1925, and shortly thereafter began his training in radiology under Dr. George W. Holmes at the Massachusetts General Hospital in Boston. Dr. Holmes has had many pupils, of whom Dr. Hampton became one of the most outstanding. Scientifically, his most fruitful years were during his association with the Massachusetts General Hospital and Harvard Medical School. On Dr. Holmes' retirement, Dr. Hampton was appointed Chief of the Department of Radiology and he served in this capacity until he entered the army to become Chief of the Radiological Service of the Walter Reed Army Hospital, where he remained for the duration of the war.

After the war, Dr. Hampton joined the group of Drs. Groover, Christie, and Merritt and headed the Department of Radiology at Garfield Hospital in Washington, maintaining his connection with the Army as Radiological Consultant to the Walter Reed Hospital. During the reorganization of the Medical Department of the Veterans Administration, he was appointed Chief Consultant in Radiology to the Medical Director. In this position, he greatly influenced the construction, equipping, and staffing of the roentgen departments of VA Hospitals throughout the country. Under his guidance, new specifications were worked out for the radiological equipment in the Veterans Administration, and these greatly affected the manufacture

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Aubrey O. Hampton, M.D.
1900-1955

of x-ray apparatus after the war, establishing a trend which is still felt.

Other organizations made use of the unusual abilities of Dr. Hampton and of his presence in the nation's capital. He was Consultant to the Clinics of the National Institutes of Health and representative of the American Roentgen Ray Society at the National Research Council. He was chiefly responsible for the creation and maintenance of a fellowship for radiological pathology at the Armed Forces' Institute of Pathology. His great interest in the fellowship was recognized by the American Roentgen Ray Society, which, after his death, named it the "Aubrey O. Hampton Fellowship of Radiological Pathology."

Outstanding among Dr. Hampton's contributions to the literature were papers on the radiologic aspects of pulmonary pathology—disease of the middle lobe, pulmonary infarction, lipoid pneumonia—and the radiology of the intervertebral disks, and a short but significant article on the diagnosis of bleeding duodenal ulcer. Most of his papers offered original ideas and became classics.

Dr. Hampton's interest covered all fields of radiology, and he exhibited the same brilliance in each. His diagnoses were usually maintained regardless of opposing arguments, and they had the remarkable quality of almost always being right. Although

systematic, didactic teaching was something that he abhorred, he was an unusually stimulating instructor. The weekly radiological seminar conducted by Drs. Holmes and Hampton at the Massachusetts General Hospital justly deserved its reputation as one of the most valuable teaching sessions for radiologists both young and old in New England.

Dr. Hampton probably was at his best as a clinical radiologist in the daily routine. He was interested in his patients, and radiology was only part of the picture. His unerring ability to see the important aspect of clinical problems was refreshing and exciting even to those who had been with him for years. It is little wonder that he had innumerable ardent clinical friends who made him the center of their investigating teams. His completely independent approach to every case and his reliance upon what he could discover with his own five senses, was constantly stimulating. He set a great example to his students of independent thinking as against complete dependence on textbook wisdom.

"Hamp" was a man of unusual charm, who made friends easily, and kept them. Although he may himself have welcomed death because of his long illness, it was a great loss to his wife, his two children, and to the many friends who survive him.

JAMES R. LINGLEY, M.D.
RICHARD SCHATZKI, M.D.



ABSTRACTS OF CURRENT LITERATURE

ROENTGEN DIAGNOSIS

The Head and Neck

- ODÉN, SVEN. Triurol in Cerebral Angiography. . . 946

The Chest

- WARNER, A. L., ET AL. The Relationship of Agnesis of the Lung to Emphysema and Cor Pulmonale. . . 946
- OCHSNER, ALTON, ET AL. Cancer of the Lung. A Review of Experiences with 1,457 Cases of Bronchogenic Carcinoma. . . 946
- KATZEV, HERBERT, AND BASS, HYMAN E. Cavitation in Metastatic Pulmonary Neoplasm. . . 947
- PIGORINI, LUIGI, AND TRICOMI, GAETANO. The Contribution of Roentgenology to the Diagnosis of Syndromes Caused by Bronchial Stenosis Following Adenopathy (Middle Lobe Syndrome and Analogous Syndromes) 947
- FINKE, H. The Differentiation of Benign Bronchostenosis and Its Relation to Atelectasis. . 947
- CIARPAGLINI, LUIGI, AND FUSI, GIORGIO. Remarks on Bronchiectasis with Emphasis on Bronchographic Aspects. . . 948
- FRIEDMAN, LOUIS L. Significant Case of Pneumonia in a Soft-Coal Worker. . . 948
- PERKINS, BLANCHE, AND BOGEN, EMIL. The Los Angeles X-Ray Survey Film and Record Library, Its Past Development, Present Activities and Future Possibilities. . . 948
- KUGEL, E., AND PÖSCHL, M. Pulmonary Tuberculosis: Roentgen Diagnostic and Therapeutic Considerations. . . 948
- STEVENSON, F. HARWOOD. The Natural History of Pleural Effusion and Orthopaedic Tuberculosis. . . 949
- BOGARDUS, GEORGE M., ET AL. Pleural Mesothelioma. Report of Four Cases. . . 949
- TAPIOVAARA, JUHA. The Pneumomediastinum. . 949
- TORSOLI, A., ET AL. Studies on the Thymus. . . 950
- WEINGARTEN, WILLIAM, AND GORDON, GLENN. Thymoma: Diagnosis and Treatment. . . 950
- POHL, R., AND SCHARFF, O. Thoracic Volume and Obesity. . . 950

The Cardiovascular System

- ELDRIDGE, FREDERIC L., ET AL. A Study of the Clinical Reactions to Venous Angiocardiography. . . 950
- McKUSICK, VICTOR A., AND COOLEY, ROBERT N. Drainage of Right Pulmonary Vein into Inferior Vena Cava. Report of a Case, with a Radiologic Analysis of the Principal Types of Anomalous Venous Return from the Lung. . 951
- POWELL, M. L., AND HILLER, H. G. Pulmonary Correlation. . . 951
- DOWNES, CHARLES R., ET AL. Aneurysm of Splenic Artery. . . 951

- HILSCHER, W. M. Venous Aneurysms. . . 951
- FELDER, D. A., AND MURPHY, T. O. The Evaluation of a Method of Phlebography of the Lower Extremities. . . 952

The Digestive System

- MOORE, JOHN R., AND MORTON, H. S. Gastric Carcinoma. A Statistical Review of 427 Cases of Carcinoma of the Stomach from 1941 through 1950. . . 952
- NIEMETZ, DAVID, AND WHARTON, GEORGE K. Benign Gastric Polyps. . . 952
- MEHTA, M. M. Perigastric Abscess. A Case Report with Preoperative Roentgen Diagnosis. . 952
- BARSKY, PERCY. The X-Ray Delineation of Ingested Enteric-Coated Substances. . . 952
- ROOT, GROSVENOR T., ET AL. Intussusception: An Eight Year Survey. . . 952
- FINERMAN, W. B. Perforations of Respiratory and Alimentary Tracts by Metallic Foreign Bodies. . . 953
- BURT, L. IAN, AND MASEL, H. Cholecystitis Glandularis Proliferans (Diverticula of the Gall-Bladder). . . 953
- GAYLIS, H., AND GUNN, KENNETH. Transduodenal Cholangiography. . . 953
- WHITEHOUSE, WALTER M. Correlation of Surgical Pathology with Telepaque Cholecystography in Doses of Two Grams. . . 953
- SILVERMAN, FREDERIC N., AND SHIRKEY, HARRY C. A Fat Absorption Test Using Iodized Oil, with Particular Application as a Screening Test in the Diagnosis of Fibrocystic Disease of the Pancreas. . . 954

Hernia

- BRANSON KATHARINE. A Case of Incarcerated Diaphragmatic Hernia. . . 954

The Musculoskeletal System

- PICK, M. PICKERING. Familial Osteochondritis Dissecans. . . 954
- GARDINER, T. B. Osteochondritis Dissecans in Three Members of One Family. . . 954
- LLOYD-ROBERTS, G. C. Osteoarthritis of the Hip. A Study of the Clinical Pathology. . . 955
- HARRISON, R. G., AND GOSSMAN, H. H. The Fate of Radiopaque Media Injected into the Cancellous Bone of the Extremities. . . 955
- KOBERG, H. The Necessity for Water-Soluble Contrast Media for Lumbar Myelography. . 955

The Spinal Cord

- HOLMAN, COLIN B., ET AL. Diastematomyelia. . 955

Gynecology and Obstetrics

- PIMBLETT, G. W., AND WHITE, T. G. E. An Assessment of the Value of Antenatal Radio-

- logical Pelvimetry Based on 500 Successive Pelvimetric Examinations. 956
- RIEMENSCHNEIDER, EDWIN A. Gas in Fetal Circulation—A Sign of Fetal Death. Case Report. 956

The Genitourinary System

- MOORE, THOMAS D., AND MAYER, RAYMOND F. Hypaque: An Improved Medium for Excretory Urography. A Preliminary Report of 210 Cases. 956
- POTTS, IAN F. Further Experiences in Aortography. 956
- ARONS, WALTER L., ET AL. Nephrocalcinosis Visible by X-Ray Associated with Chronic Glomerulonephritis. 957
- IMBER, IRVING, AND CLYMER, ROBERT H., JR. Obstruction of the Renal Artery Producing Malignant Hypertension. 957

Miscellaneous

- GOETSCH, E. Roentgenologic Findings in Diffuse Scleroderma. 957
- SALOMON, A., ET AL. Scleroderma. Pulmonary and Skin Studies Before and After Treatment with Cortisone. 957
- CLARKE, NORMAN E., ET AL. The "In Vivo" Dissolution of Metastatic Calcium. An Approach to Atherosclerosis. 957

Technic

- PAATERO, YRJO V. The Principles of the Construction and Function of the Stereo-Pantomograph. A Device for Stereoscopic Pantomography with a Single Exposure. 958
- ODEBLAD, ERIK. Pin-Hole Autoradiography. 958
- FARR, R. F. The Specification of Roentgen Ray Output and Quality. 958

RADIOTHERAPY

- MÜLLER-MINY, HERIBERT. The Treatment of Malignant Melanomas. 959
- RAI, K. M. Malignant Lymphoma: Radiological Aspects. 959
- WANKE, R. Problems in the Therapy of Breast Cancer. 959
- GRAHAM, JOHN B., AND GRAHAM, RUTH M. The Curability of Regional Lymph Node Metastases in Cancer of the Uterine Cervix. 959
- DODDS, J. R., AND LATOUE, J. P. A. Carcinoma of the Cervical Stump. 960
- TURNBULL, A. C. Radium Menopause or Hysterectomy. Part I. The Effects of the Radiation Menopause. A Controlled Study. 960
- COSTOLOW, WM. E., AND WISDOM, WM. R. Radiation Therapy in Retroperitoneal Tumors. 960
- FRECKER, E. W. Radiotherapy in Bladder Carcinoma. 961
- RAINES, SAMUEL L., AND HURDLE, THOMAS G. Tumors of the Testis. 961

- TOCHILIN, E. A Photographic Method for Measuring the Distribution of Dosage from Radium Needles and Plaques. 961

RADIOISOTOPES

- ZIEVE, LESLIE, ET AL. Comparative Value of the Basal Metabolic Rate, Chemical Protein-Bound Iodine, and Radioactive Iodine Excretion or Uptake in the Diagnosis of Borderline Hyperthyroidism when Used Individually or in Combination. 962
- HIMANKA, ERKKI, AND LARSSON, LARS-GUNNAR. Estimation of Thyroid Volume. An Anatomic Study of the Correlation Between the Frontal Silhouette and the Volume of the Gland. 962
- INGBAR, SIDNEY H. Simultaneous Measurement of the Iodide-Concentrating and Protein-Binding Capacities of the Normal and Hyperfunctioning Human Thyroid Gland. 962
- POBIRS, FREDERICK W., AND JAFFE, HENRY L. Radioactive Iodine Therapy in Euthyroid Cardiac Patient with Previous Mitral Commissurotomy. 962
- HINMAN, FRANK, JR., ET AL. Further Experience with Intracavitary Radiocobalt for Bladder Tumors. 963
- VERMOOTEN, VINCENT. Use of Radioactive Cobalt (Co_{60}) in Nylon Sutures in Treatment of Carcinoma of Bladder: Preliminary Report. 963
- JACOBSON, LILLIAN E., AND KNAUER, ISABELLE S. Stray Radiation Measurements Around a Cobalt 60 Beam Therapy Installation. 963
- HULTBORN, K. A., AND JONSSON, L. I. The Use of Colloidal Au^{198} for the Detection of Lymph Nodes in Radical Excision of the Breast. 963
- HULTBORN, K. A., ET AL. A Study of the Lymph Drainage of the Lower Limb with the Use of Colloidal Radiogold (Au^{198}). 964
- WHEELER, H. BROWNELL, ET AL. Experiences with the Use of Radioactive Colloidal Gold in the Treatment of Cancer. 964
- NELSON, CHARLES M., AND WILLIAMS, GEORGE Z. The Use of Radioactive Gold Colloid in Inoperable Carcinoma of the Bladder. 964
- TALAIRACH, J., ET AL. A New Method of Treatment of Inoperable Brain Tumours by Stereotaxic Implantation of Radioactive Gold. A Preliminary Report. 965
- COWAN, IRVING I., AND KARIOIS, FRANK G. Prophylaxis and Palliation of Malignant Effusions with Radioactive Colloidal Gold. 965
- LOUGH, S. ALLAN. Colloidal Gold Infusion Unit. 965
- MOORE, VINCENT, ET AL. Radioactive Chromic Phosphate in Treatment of Urological Tumors. 965
- ROTHENBERG, SANFORD F., ET AL. Hypophysectomy with Radioactive Chromic Phosphate in Treatment of Cancer. 965

- 1955
961
962
962
963
963
963
963
964
964
965
965
965
965
965
- SOGNNAES, REIDAR F., ET AL. Radiotracer Studies on Bone, Cementum, Dentin and Enamel of Rhesus Monkeys. 965
- GLASS, GEORGE B. JERZY, ET AL. Surface Scintillation Measurements in Humans of the Uptake of Parenterally Administered Radioactive Vitamin B₁₂. 966
- HINE, G. J., ET AL. Scintillation Counting for Multiple-Tracer Studies. 966
- LEROV, GEORGE V. Clinical Research Using Compounds with Labeled Radioactive Carbon and Hydrogen as Tracers. 966
- THREEFOOT, S. A., ET AL. The Biologic Decay Rates and Excretion of Radiocesium, Cs¹³⁴ with Evaluation as a Tracer of Potassium in Dogs. 967

RADIATION EFFECTS

- 962
962
963
963
963
964
964
965
965
965
965
965
- HUTAFF, LUCILE W., AND BELDING, HELEN W. The Effects of Irradiation of the Pelvis in

- Patients with Carcinoma of the Cervix Uteri on the Iliac and Sternal Marrow and on the Peripheral Blood. 967
- PETERS, HANNAH. Tolerance Dose and Permissible Weekly Exposure to X and Gamma Radiation. 967
- LOONEY, WILLIAM B. Late Clinical Changes Following the Internal Deposition of Radioactive Materials. 967
- HALEY, THOMAS J., ET AL. Response of the Burro to 100 r Fractional Whole Body Gamma Ray Irradiation. 968
- CLEMEDSON, CARL-JOHAN, AND NELSON, ARNE. Effects of Combined Whole Body Roentgen Irradiation and High Explosive Blast Injury in Mice. 968
- FORSBERG, ARNE G., AND HEVESY, GEORGE. Effect of X-Rays and Hormones on Resorption Rate of Injected NaHC¹⁴O₃. 968
- SCHUBERT, G. The Problem of Radioreistance in Biology and Medicine. 968



ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Triurol in Cerebral Angiography. Sven Odén. *Acta radiol.* 43: 97-103, February 1955.

According to the author, "the ideal contrast medium in cerebral angiography should meet the following requirements: its use should not entail any risk of complications at the time of the examination nor any discomfort to the patient, it should not cause late damage, and it should be rapidly and easily eliminated from the organism." With these requirements in mind, he has used Triurol, a Urokon preparation of Swedish manufacture. He conducted a comparative study of this medium and Umbradil (Diodrast) by means of double examinations in 102 cases.

Triurol was found to cause much less discomfort to the patient than Umbradil and was therefore adopted for routine use. It had been employed at the time of this report in an additional 142 patients. In 1 case a delayed transient generalized urticaria developed. Because of this, 2 ml. of Triurol is now injected intravenously the day before the examination to test for sensitivity.

Three angiograms. RICHARD E. OTTOMAN, M.D.
University of California, L. A.

THE CHEST

The Relationship of Agenesis of the Lung to Emphysema and Cor Pulmonale. A. L. Warner, N. M. Palladino, W. Schwartz, and A. Schuster. *J. Pediat.* 46: 200-209, February 1955.

A case of agenesis of the lung with associated atopy in an 8-year-old Negro male is reported. Bronchoscopic examination showed the right side of the tracheobronchial tree to be normal. Bifurcation, however, was absent, with no suggestion of even a rudimentary left bronchus. Roentgenograms of the chest revealed a marked diminution of the volume of the left hemithorax and an associated scoliosis of the dorsal spine. The heart shadow was displaced into the left hemithorax, in which it was situated slightly posteriorly. The right lung was emphysematous and extended into the left hemithorax through the anterior mediastinum.

Bronchograms revealed complete absence of the left main stem bronchus and its branches. The aerated lung tissue occupying the left hemithorax was supplied by a bronchus arising from the right main stem bronchus in the region corresponding to the normal site of origin of the right middle lobe bronchus. The remaining bronchi of the right lung showed rather marked separation. The medial basal or cardiac segment of the lower lobe was displaced across the mid-line, and the anterior segment was situated slightly higher than normal.

Angiocardiography disclosed a large main pulmonary artery and absence of the left main pulmonary artery. The right main pulmonary artery and its branches appeared unusually prominent, which was thought to indicate cor pulmonale.

Extensive laboratory tests of pulmonary function revealed the following abnormalities: (1) arterial O₂ saturation 94.4 per cent; (2) residual volume 985 ml. and residual volume/total lung capacity (N. 20.4 per cent) 44 per cent; (3) CO₂ uptake 21 and 44 per cent.

Slight arterial O₂ unsaturation was perhaps attributable to mild diffusion impairment. The presence of a low CO₂ uptake supports this possibility.

A review of the literature showed the mortality rate of agenesis of the lung to be 75 per cent in patients less than one year of age. This very high figure was largely due to associated anomalies. An older group (up to forty-one years) showed a 5 per cent mortality rate. Although most of these patients do not have respiratory symptoms, there are reports of effort dyspnea and, rarely, of cyanosis.

Five roentgenograms; 3 tables.

HOWARD L. STEINBACH, M.D.
University of California, S. F.

Cancer of the Lung. A Review of Experiences with 1,457 Cases of Bronchogenic Carcinoma. Alton Ochsner, C. Jack Ray, and Page W. Acree. *Am. Rev. Tuberc.* 70: 763-783, November 1954.

Pulmonary cancer is increasing in incidence more than any other neoplasm. In 1920, 1.1 per cent and, in 1948, 8.3 per cent of all carcinomas reported in the United States originated in the lung. This difference, the authors believe, is due almost wholly to the great increase in cigarette smoking. Experimental work has shown that cigarette smoke contains a carcinogen. In addition, recent study has demonstrated definite metaplastic changes, probably precancerous, in the bronchi of heavy smokers dying from other causes. No such lesions were found in bronchi of non-smokers of the same age group.

In a review of 1,457 cases of lung cancer, the authors found the right lung to be involved in 54 per cent. The upper lobes were involved in 56 per cent. The most frequent cell type was the epidermoid, which was found in 49.4 per cent, with 31.5 per cent undifferentiated and the remaining 19.1 per cent adenocarcinoma. There was a considerable difference in cell type in the sexes, with 53 per cent epidermoid carcinoma in males and only 21 per cent of that type in females. Ninety-five per cent of the epidermoid carcinomas, 89 per cent of the undifferentiated, and 69 per cent of the adenocarcinomas were found in males. Adenocarcinomas had a greater tendency to occur peripherally than the epidermoid tumors.

Symptoms, in order of occurrence, were cough, weight loss, chest pain, hemoptysis, respiratory infection, dyspnea, weakness, wheeze, night sweats, and voice change. Asymptomatic lesions were the exception, but many patients were found to have far advanced tumors before symptoms occurred.

The diagnosis is usually made on roentgenographic examination of the chest. Lesions originating in the hilar areas are the most difficult to detect. Cytologic examination of the sputum or bronchial washings will usually confirm the presence of a cancer, but in 20 per cent of this series, exploratory thoracotomy was necessary.

Treatment consisted of pneumonectomy with an *en bloc* excision of all of the mediastinal nodes where this was possible. Resections were performed on 32.1 per cent of the group. In 73 per cent of these cases the resection was considered as palliative, but 6.6 per cent of this number lived five years. For the entire resected group the five-year survival rate was 13.5 per

cent and for patients in whom the lesion was apparently limited to the lung 31 per cent. An average delay of 8.7 months from the onset of the first symptoms to the institution of therapy was thought to be at least partially responsible for the fact that only 49 per cent of the cases were operable and of those only 32 per cent were resectable. Many of the delays were caused by interpretation of shadows on the roentgenograms as atypical pneumonia.

The authors believe that all men past the age of forty who have been heavy smokers should have a routine chest roentgenogram at least every six months and possibly every three months. All shadows should be considered suspicious of carcinoma, since it is obvious that the diagnosis of bronchogenic carcinoma must be made earlier in order to increase the salvage rate.

Twenty-three figures.

JOHN H. JUHL, M.D.
University of Wisconsin

Cavitation in Metastatic Pulmonary Neoplasm. Herbert Katzev and Hyman E. Bass. *Dis. of Chest* 27: 225-227, February 1955.

The authors report a case of metastatic pulmonary carcinoma with cavitation, citing the paucity of such reports in the literature. The patient was a 66-year-old male with a history of removal of a primary adenocarcinoma of the transverse colon eight years earlier. Roentgen examination disclosed multiple nodular lung densities with atelectasis. The hilar nodes were enlarged and the right upper lobe showed a pneumonic density suggestive of atelectasis, with a cavity at its outer aspect. The cavitation was shown at autopsy to be due to extensive degeneration and necrosis of tumor tissue. In addition to the metastatic carcinoma, the patient had an acute myeloid leukemia which (as the history indicates) played a major role in his demise.

The authors feel that the occurrence of cavitation in metastatic pulmonary nodules may become more frequent in this era of extensive antimicrobial therapy, when the duration of life may be extended, and that carcinoma will become a more serious consideration in the differential diagnosis of lung cavitation.

One roentgenogram. F. F. RUZICKA, JR., M.D.
St. Vincent's Hospital, N. Y.

The Contribution of Roentgenology to the Diagnosis of Syndromes Caused by Bronchial Stenosis Following Adenopathy (Middle Lobe Syndrome and Analogous Syndromes). Luigi Pigorini and Gaetano Tricomi. *Radiol. med. (Milan)* 41: 143-156, February 1955. (In Italian)

The term "middle-lobe syndrome" coined by Brock in 1946, is used to designate non-specific parenchymatous changes (from simple atelectasis and/or obstructive pneumonitis to severe bronchiectasis and/or abscess formation) caused by irreversible bronchial damage (stenosis) due to constricting adenopathy, the latter being usually, but not necessarily, of tuberculous origin. This syndrome may affect other lobes (right upper or left lower) or segments of lobes, but there exists a predilection for the right middle lobe, perhaps because it is cornered by two interlobar fissures containing lymph channels susceptible to the induction of a sclerosing process after involvement in the causative adenopathy. The maximum incidence is in the fourth decade. There is no characteristic clinical picture, and the symptomatology (fever, weight loss, cough, purulent and/or sanguinolent expectoration, etc.), consistent with the

degree of inflammatory activity, may simulate any respiratory ailment, from acid-fast infection to carcinoma. Early diagnosis is essential, since timely lobectomy effects lasting cure.

The characteristic roentgen feature of the middle lobe syndrome is a density, the shape, size, and opacity of which vary with the underlying pathological changes. At times the shadow is so faint that it can be missed on the frontal film, and lateral or exaggerated lordotic (Fleischner's) views become necessary for its proper demonstration.

Further information can be obtained with specialized procedures. The incriminated bronchus, for example, can be investigated by bronchography. In a benign or malignant tumor there will be abrupt transition from the uninvolved to the diseased area of the bronchial wall, and frequently interruption of the airway; in the middle lobe syndrome a relatively long portion of the bronchus appears diseased, while complete occlusion is seldom encountered, though it may occur after a long illness. The contrast medium may reveal similarly damaged and stenosed walls in other segments of the bronchial tree (the original adenopathy is not necessarily localized) or it may show segmental readjustments, intended to compensate for the diminution of space, which occurs only in long-standing conditions.

Body-section radiography may demonstrate a cluster of calcified lymph nodes around the root of the involved bronchus. It is also of help in differentiating a cancer, i.e., an expanding and infiltrating, intra- or extra-luminal space-occupying lesion, which displaces and distorts the adjacent bronchi.

Bronchoscopy, including cytologic studies of the collected secretions and/or histologic examination of biopsy specimens, should be performed in all cases. Proper evaluation must include the clinical as well as the laboratory findings, even though the largest contribution, short of surgery or autopsy, comes from the x-ray examination. To appreciate the radiologist's difficulties, one must realize that even the experienced microscopist may not always be able to distinguish metaplastic bronchial mucosa from early malignant change.

Twenty-two roentgenograms; 1 drawing.

E. R. N. GRIGG, M.D.
Cook County Hospital

The Differentiation of Benign Bronchostenosis and Its Relation to Atelectasis. H. Finke. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 82: 217-223, February 1955. (In German)

Bronchostenosis usually results in diminished aeration of pulmonary segments or lobes and finally in atelectasis when the stenosis becomes complete. When, however, a check-valve or ball-valve mechanism exists at the site of the obstruction, the air will be trapped during inspiration and unable to escape during expiration. Such a mechanism will result in various degrees of obstructive emphysema instead of an atelectasis.

The roentgenographic appearance of atelectasis is discussed, and it is pointed out that in chronic cases edema and venous engorgement will cause the atelectatic area to become so dense as to simulate pneumonic consolidation. In all cases of suspected bronchostenosis it is important to localize the lesion with the aid of tomography, bronchoscopy, and bronchography.

The author points out that bronchogenic carcinoma

is not the only cause of atelectasis, but that an underlying "benign bronchostenosis" is found even more frequently. The following causes are cited: foreign bodies, plugs formed by secretions and by blood clots, granulation tissue and inflammatory stenotic processes, perforation of caseous lymph nodes into the bronchial lumen, and ulcerative endobronchial tuberculosis with resulting stenosis.

Six representative cases are briefly reported to illustrate the various causes of so-called benign bronchostenosis. In the sixth case an endobronchial adenoma with check-valve mechanism had caused an obstructive emphysema instead of an atelectasis.

It is important to detect the cause of atelectasis without delay, since prompt correction may sometimes result in complete cure.

Eleven roentgenograms. ERNEST KRAFT, M.D.
Newington, Conn.

Remarks on Bronchiectasis, with Emphasis on Bronchographic Aspects. Luigi Ciarpaglini and Giorgio Fusi. *Radiol. med.* (Milan) 41: 97-142, February 1955. (In Italian)

Bronchial dilatations may be acquired or congenital. A pathogenetic classification of the latter group includes (A) the *embryonal* type, due to (a) alterations of the germ plasm, (b) compression by Cuvier's duct, (c) compression by the branches of the left pulmonary artery, or (d) compression by the azygos vein, and (B) the *fetal* type, which may be due to (a) alveolar agenesis, (b) delayed resolution of fetal atelectasis, or (c) transplacental infection. After a review of the mechanical and infectious factors in acquired bronchiectasis, 19 cases are reported in detail. The bronchographic medium used in this series (Radiopol-sulfamidico) contains a sulfa compound, to prevent retention of iodinated oil.

From a descriptive (bronchographic) point of view, bronchiectases are included in the following categories: (1) so-called cystic, (2) predominantly saccular, (3) predominantly cylindrical, and (4) with abscess formation. It is believed that cases in the first category are more often of dysplastic (developmental) etiology. Nevertheless, in the authors' opinion, it is not possible to determine the origin of bronchiectases from their bronchographic appearance.

Sixty-five roentgenograms; 1 drawing.
E. R. N. GRIGG, M.D.
Cook County Hospital

Significant Case of Pneumoconiosis in a Soft-Coal Worker. Louis L. Friedman. *Arch. Int. Med.* 95: 328-332, February 1955.

A fatal case of disabling progressive pneumoconiosis in a soft-coal worker following removal from exposure to the dust is presented.

A 57-year-old white male had worked underground for twenty-nine years. When first seen, he complained of shortness of breath, cough, and pain in the chest. Serial roentgenograms made over a five-year period showed progression from emphysema and symmetrical linear infiltrates in both lungs to conglomerate lesions of the upper lobes, which increased in size and underwent cavitation. Pulmonary nodulation was not demonstrated. Repeated studies showed no evidence of tuberculosis. Histopathologic examination revealed classic discrete silicotic nodules in both lungs.

This type of pneumoconiosis results from inhalation

of soft-coal dust, usually in association with varying amounts of silicon dioxide. However, coal dust relatively free of silicon dioxide may itself produce a crippling and fatal pneumoconiosis.

The diffuse symmetrical nodulation typical of silicosis is relatively uncommon in soft-coal workers' pneumoconiosis. Emphysema and diffuse linear changes may be the only roentgenographic manifestations of clinically significant disease. There is poor correlation between the roentgenographic appearance of the lungs and clinical symptomatology.

Eight roentgenograms; 2 photographs.

THEODORE E. KEATS, M.D.
University of California, S. F.

The Los Angeles X-Ray Survey Film and Record Library, Its Past Development, Present Activities and Future Possibilities. Blanche Perkins and Emil Bogen. *Dis. of Chest* 27: 128-133, February 1955.

The authors discuss the various benefits that have already resulted and others which may be expected from the Los Angeles survey film project of 1950, which cost more than \$1,200,000 and in which 2,000,000 microfilms and 55,000 large films were taken (see *Absts. in Radiology* 64: 610, 613, 1955). They point out the many types of information that such a survey affords with respect to the immediate data, as well as the many studies which such information, previously unavailable, has made possible.

As a preliminary to the statistical analysis of the survey material, a census tract index of all addresses in the entire county was prepared. This proved useful not only for the survey but also to various departments of the county government. For example, correlation of the incidence of tuberculosis as determined in the survey with the census tracts has resulted in useful information to the health department.

A duplicate set of records of old films has been arranged alphabetically. This alphabetizing makes possible other investigations not previously available. Comparison of findings on repeat films of the same individual has given valuable information regarding the reliability of the reading of the films as well as the development of tuberculosis in short periods of time. Similarly the survey population can be checked against the newly reported cases of tuberculosis and deaths from tuberculosis in the county.

The extensive clinical material represented by these 2,000,000 films is of obvious value in a large variety of anthropometric, anatomic, and physiologic studies. Every year the development of new instances of tuberculosis, cancer, and heart disease makes possible further study of the value of the survey in disclosing and predicting the occurrence of such conditions.

The work of the film library has shown no sign of decreasing during the three years since completion of the survey. Scores of requests from patients, private physicians, county and city officials arrive at the library daily for both films and information.

One table.
F. F. RUZICKA, JR., M.D.
St. Vincent's Hospital, N. Y.

Pulmonary Tuberculoma: Roentgen Diagnostic and Therapeutic Considerations. E. Kugel and M. Pöschl. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 82: 212-216, February 1955. (In German)

Pulmonary tuberculoma is either a primary or secondary tuberculous focus with a sharply demarcated and

rounded contour. It is usually not over 4 cm. in diameter and is located predominantly in an upper lobe below the clavicle. Associated characteristic changes are either fibrotic strands or linear tail formations leading to the hilus. Chronic bronchitis is frequently present and hilar nodes are often enlarged. An old calcified complex may also be found.

Tomography is distinctly helpful for proper localization and for detection of small satellites sometimes present in the immediate vicinity of the tuberculoma. Bronchography is fraught with danger, as it may activate a silent tuberculous process, but it may become necessary, when other procedures fail, for accurate preoperative localization.

Clinically, the tuberculoma is usually silent, and in two-thirds of the cases the sputum will remain negative for acid-fast organisms preoperatively. Perforation of the focus into an adjacent bronchus may occur. Such complication causes spread of the disease and, in its early phase, may be suggested by an area of lessened density within the tuberculoma. In view of a potential danger of reactivation, surgical removal is advised, whenever feasible.

In the differential diagnosis benign and malignant tumors, either primary or metastatic, dermoid cysts, echinococcosis and bronchial cysts can sometimes be excluded, especially when other tuberculous changes are present. Non-tuberculous processes tend to increase in size and, when hemoptysis occurs in these cases, the sputum will remain negative for acid-fast organisms, in contradistinction to tuberculoma.

Five roentgenograms; 1 photomicrograph.

ERNEST KRAFT, M.D.
Newington, Conn.

The Natural History of Pleural Effusion and Orthopaedic Tuberculosis. F. Harwood Stevenson. *J. Bone & Joint Surg.* 37-B: 80-91, February 1955.

Having observed the association of pleural effusion with bone tuberculosis and an apparent absence of the disease in the lungs, the author kept a subsequent record of all patients with effusions prior to bone involvement or developing thereafter, with or without treatment.

Details are given of 63 such effusions seen over a period of seven years. Twenty-four of these occurred before the onset of symptoms of the orthopaedic lesion. The bone and joint lesions ultimately developing in this group of patients were widely scattered throughout the skeleton. Three others, also preceding the onset of bone lesions, were probably secondary to adult-type pulmonary disease. Thirty-six patients had a pleural effusion after the beginning of the orthopaedic tuberculous history. Seven were certainly secondary to operative intervention, 6 in the thorax near the parietal pleura (costotransversectomy or anterolateral decompression of the cord) and 1 from a hematogenous dissemination after fusion of a hip joint. Of the 29 patients with pleural effusion developing during the history of the orthopaedic tuberculous disease, 25 suffered from disease of the thoracic spine; 2 had lesions in the lumbar spine; in 2 details were lacking.

The conclusion is drawn that the overwhelmingly common cause of pleural effusion in patients with orthopaedic tuberculosis who have normal lungs and have not recently suffered spinal decompression is transpleural infection from thoracic spinal disease and that this sequence is by no means rare. It had occurred

in approximately 1 in 6 of 145 patients with thoracic Pott's disease seen during this investigation. Details are also given of a group of cases of pleural effusion secondary to thoracic paravertebral abscess extending laterally. Aspiration will yield pus from such posterior extrapleural abscess extensions.

The belief that Pott's disease most commonly follows direct spread from caseous para-aortic glands secondary to tuberculous pleurisy is discussed. It is concluded that the evidence is insufficient for so sweeping a statement.

Thirteen roentgenograms; 1 drawing; 6 tables.

JOSEPH P. TOMSULA, M.D.
Baton Rouge, La.

Pleural Mesothelioma. Report of Four Cases.

George M. Bogardus, Kenneth P. Knudtson, and Waldo H. Mills. *Am. Rev. Tuberc.* 71: 280-290, February 1955.

Four cases of primary mesothelioma of the pleura are reported. Three of these tumors were of the solitary type, and 2 of these were considered malignant. One malignant diffuse mesothelioma is included.

The diffuse form usually produces widespread thickening of the pleura covering the lung, diaphragm, pericardium, and thoracic wall. The tumor invades the underlying tissues superficially and usually does not metastasize, though in some instances metastases are found in the regional lymph nodes or at distant sites.

The solitary tumor is usually sharply circumscribed and pedunculated, often projecting into the pleural cavity. The lung or soft tissues of the thoracic wall may be indented. The benign solitary tumors grow slowly and may reach a large size before being discovered. The malignant tumors may have a broad attachment to the pleura and infiltrate the tissues of the chest wall or lung. In spite of histologic evidence of malignancy, the solitary tumors tend to infiltrate locally and frequently do not metastasize until late, and thus, if diagnosed early, may be completely excised.

The presence of a mesothelioma of the pleura should be suspected in all patients having rheumatic symptoms associated with a circumscribed intrathoracic tumor.

Three roentgenograms; 3 photographs; 5 photomicrographs.

THEODORE E. KEATS, M.D.
University of California, S. F.

The Pneumomediastinum. Juha Tapiovaara. *Acta radiol.* 43: 104-112, February 1955.

Pneumomediastinum was produced indirectly in 30 patients by slowly injecting into the presacral tissue spaces 1,500 ml. of oxygen at a pressure of 20 to 22 cm. of water. By altering the patient's position from time to time to allow diffusion of the oxygen upward through the retroperitoneal spaces, the gas could usually be made to enter the mediastinum within an hour to an hour and a half. With the mediastinal structures clearly defined, tomography was employed to obtain additional information about thoracic lesions, such as the site of origin or degree of infiltration.

No untoward effects are reported. Only 2 patients complained of pressure sensations and pain in the upper abdomen, which was relieved when the gas entered the thorax.

Three illustrative cases are included.

Nine roentgenograms.

RICHARD E. OTTOMAN, M.D.
University of California, L.A.

Studies on the Thymus. A. Torsoli, G. Sarteschi, M. Mele, and E. Sbrana. *Radiol. med. (Milan)* 41: 157-179, February 1955. (In Italian)

The fact that the thymus persists in adolescents and adults much more frequently than previously believed was confirmed in a series of 50 persons of both sexes, aged five months to sixty years. The examination included routine frontal and lateral chest views as well as transverse axial stratigraphy performed before and after pneumomediastinum, the gas being insufflated either retrosternally or by the less hazardous precoccygeal (retroperitoneal) route.

The shape of the anterior mediastinum varies with the level to which stratigraphy is directed. It is tapeziform at T3-T4, triangular at T5-T6, and hemispheric at T6-T7 and beyond. As a rule, the thymus will not be found above T3 nor below T7.

With the experience gained from pneumomediastinum and transverse axial stratigraphy, the thymus can be identified in retrospect on some of the standard exposures. The borderline between average size and enlargement of the gland (enlargement does not necessarily mean disease) is hard to define: for practical purposes, the thymus is considered enlarged if (1) in the adolescent and adult there is demonstrable encroachment upon the free retrosternal space (levels T3-T4 and T4-T5), while (2) in the infant this space must be completely obliterated.

Because of considerable variation in the amount of functional thymic tissue as compared with the fibrolipomatous stroma, simple radiovolumetry is not satisfactory. This is brought out by the frequent discrepancy in the relationship between gland size and various endocrinopathies or even between gland size and body weight.

In this series, 3 patients received roentgen therapy over the presteral region, and 2 patients were treated with thymotoxic substances (ACTH and cortisone). Prior to therapy, the thymus was of homogeneous, fairly opaque density, well circumscribed. Afterward, its margins had become ragged, moth-eaten, and less dense, resembling the appearance encountered in spontaneous regression of the thymus in older persons. If confirmed, this observation would indicate the possibility of a functional evaluation from the radiographic aspect. Moreover, with increased experience, the thymus shadow can be identified by use of transverse axial stratigraphy even in the absence of pneumomediastinum.

Forty-seven roentgenograms.

E. R. N. GRIEG, M.D.
Cook County Hospital

Thymoma: Diagnosis and Treatment. William Weingarten and Glenn Gordon. *Ann. Int. Med.* 42: 283-295, February 1955.

Four cases of thymoma are presented, illustrating the difficulty sometimes encountered in making the diagnosis. Thymomas are sometimes asymptomatic and are discovered only on routine chest examinations. Others give symptoms due to compression of the mediastinal structures. In about 15 per cent there is associated myasthenia gravis.

Sometimes the tumor may be found in locations other than retrosternally. Examples have been encountered at the level of the ninth and tenth thoracic vertebrae, above the diaphragm, in front of the pericardium, and on the anterior surface of the left main stem bronchus.

The authors stress thorough investigation of all tumors found in the anterior mediastinum with early thoracotomy if necessary to confirm the diagnosis.

Eleven roentgenograms.

G. J. WOOLHANDLER, M.D.
VA Center, Shreveport, La.

Thoracic Volume and Obesity. R. Pohl and O. Scharff. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 82: 223-228, February 1955. (In German)

In spite of intensive studies and observations, the development of obesity cannot be entirely explained on the basis of either high caloric intake or hormonal or constitutional factors. Equally unexplained is an observation of the authors that a seemingly large thorax in the short stocky female actually contains a small lung. [Practical application of this knowledge will result in a 50 per cent film saving.—E. K.] Not only is the transverse diameter of the chest diminished, but also its height and depth. The basal metabolic rate is at the lower normal limits, and vital capacity of the lungs is lowered by 50 per cent. No mention is made of the effect of the "small lung" on the circulation, the heart size, or the blood pressure.

Four roentgenograms; 2 photographs.

ERNEST KRAFT, M.D.
Newington, Conn.

THE CARDIOVASCULAR SYSTEM

A Study of the Clinical Reactions to Venous Angiocardiography. Frederic L. Eldridge, Herbert N. Hultgren, Chi Kong Liu, and Margaret Blumenfeld. *New England J. Med.* 252: 259-263, Feb. 17, 1955.

Clinical reactions are analyzed in 120 cases selected from a total of 300 patients subjected to venous angiography. Reactions are divided into two general groups: (1) mild or fairly innocuous and (2) severe. The latter included apnea, laryngeal spasm, Cheyne-Stokes respiration, cardiac arrhythmia, shock, pulmonary edema, convulsions, syncope, prolonged mental confusion, and death. Only one-fourth of the studied patients had no untoward reactions of any kind; in one-third severe reactions developed.

Studies were performed with three contrast media: 70 per cent Diodrast, 75 per cent Neo-Iopax, and 70 per cent Urokon. One severe reaction with death, occurred among the 24 patients receiving Urokon, a rate of 4 per cent, as compared with 32 per cent severe reactions for Neo-Iopax and 46 per cent for Diodrast.

With Diodrast, the most important single factor in the development of severe reactions apparently is the size of the dose. Dosages of less than 1 c.c. per kilogram of body weight seldom produced a severe reaction while doses above 1 c.c. were much more prone to cause difficulty. With Neo-Iopax, the incidence of reactions was about the same throughout the dosage range. Except for the one death, there were no severe reactions to Urokon. Patients with congenital cyanotic heart disease, particularly in the lower age groups, showed an increased rate of severe reaction. These are the patients who tended to receive larger total doses relative to body weight. Two patients with obstruction of the superior vena cava suffered severe reactions. No correlation could be found between materials used for premedication or anesthesia and the incidence of severe reactions.

The authors summarize 6 cases in which death fol-

lowing angiocardiology in their hospital, a mortality of 2 per cent. They point out that all 6 of the fatalities occurred in patients in very poor general condition. With a single exception the fatal reactions occurred several hours after injection of the contrast medium so that the deaths are not considered to represent "unusual" or "sensitivity" reactions to the agents.

In this series the percentage of severe reactions was much less with Urokon than with either of the other two investigated media. There were, however, 3 delayed deaths following the use of Urokon, so that further study is necessary before the ultimate safety of this drug can be determined.

Six tables.

JAMES W. BARBER, M.D.
Cheyenne, Wyo.

Drainage of Right Pulmonary Vein into Inferior Vena Cava. Report of a Case, with a Radiologic Analysis of the Principal Types of Anomalous Venous Return from the Lung. Victor A. McKusick and Robert N. Cooley. *New England J. Med.* 252: 291-301, Feb. 24, 1955.

A case of drainage of a right pulmonary artery into the inferior vena cava is reported and the radiologic features of 19 other cases representing eight varieties of anomalous venous return are reviewed. In retrospect, it appears that in 11 cases the anomaly should have been suspected from the plain chest film. In 5 cases the diagnosis was suggested or established by angiocardiology.

In general, the characteristic features of the chest film are: (1) a sickle-shaped, comma-like shadow in the right lung field, (2) a bulge of the right heart border, (3) an inconspicuous left heart border. Angiocardiology usually reveal the dilatation of the right atrium, right ventricle, and pulmonary artery. On the first circulation of the contrast material, there is likely to be considerable dilution at the point in the superior vena cava or in the right atrium where the stream of pulmonary blood joins the systemic venous return. The superior vena cava may enlarge abruptly at this point. Recirculation through the right side of the heart or continuous opacification of these chambers can usually be demonstrated. The anomalous veins are often outlined satisfactorily and their drainage demonstrated at the same time in the series when the normal pulmonary veins are filled.

Anomalous drainage of the types described is compatible with long life. Functional disability is slight and usually late in onset. The fundamental abnormality is the shunting back, to the right side of the circulation, of blood which normally passes into the left atrium and the systemic circulation. This amounts to the same thing as a defect of the interatrial septum, producing some radiologic similarities. There may be partial or total drainage of venous blood from the lung to the right side of the heart. When the transposition is total, there must, of course, be a compensatory defect within the heart to permit some venous blood from the lung to reach the systemic circulation. Usually this is an interatrial defect.

Patients with total transposition have mild or intermittent cyanosis. In such cases there may be gradual closure of the foramen ovale with increasingly severe symptoms leading to death in the first year or years of life. Hypertrophy of the right ventricle is a result of the increased volume of blood in the pulmonary circulation. The right atrium dilates. The left atrium diminishes in size. Dilatation of the main pulmonary ar-

tery is a radiologic feature of all cases. The associated malformation which permits right-to-left shunting plays its part in determining the radiologic picture. Associated pulmonary stenosis may occur, reducing pulmonary blood flow and the degree of hypervascularity of the lungs. An accompanying tetralogy of Fallot reduces the strain on the right ventricle, making it less prominent.

Fifteen roentgenograms; 14 drawings.

DONALD DEF. BAUER, M.D.
Coos Bay, Ore.

Pulmonary Coarctation. M. L. Powell and H. G. Hiller. *M. J. Australia* 1: 272-273, Feb. 19, 1955.

The authors report what they believe to be the fifth case of pulmonary coarctation in the literature, 1 case having been described by Shumacker and Lurie (*J. Thoracic Surg.* 25: 173, 1953) and 3 by Sondergaard (*Danish M. Bull.* 1: 46, 1954). The present case appears to be the first of pure pulmonary coarctation recorded, and the first with angiocardiology demonstration of the abnormality. Angiocardiology showed narrowing of both right and left pulmonary arteries at the bifurcation of the main pulmonary artery proximal to the narrowing.

Two radiographs.

SHOZO IBA, M.D.
Downey, Calif.

Aneurysm of Splenic Artery. Charles R. Downs, Alan R. Hopeman, William A. Todd, Jr., and Carleton Mathewson, Jr. *Ann. Surg.* 141: 268-272, February 1955.

Rupture of an aneurysm of the splenic artery, into either the peritoneal cavity or the gastrointestinal tract, is an unusual cause of acute blood loss. The condition should be kept in mind, however, since, if the proper diagnosis is made, splenectomy may be curative. A disproportionate number of the reported cases of intraperitoneal rupture have occurred in pregnancy, usually during the last trimester. A case is reported of a false aneurysm of the splenic artery which ruptured into the gastrointestinal tract, was diagnosed by aortography, and was successfully treated by splenectomy.

One roentgenogram; 2 photographs.

WYNTON H. CARROLL, M.D.
Shreveport, La.

Venous Aneurysms. W. M. Hilscher. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 82: 244-247, February 1955. (In German)

Aortic aneurysms as well as arterial and arteriovenous aneurysms are well known, but venous aneurysms are almost unheard of. According to the author, only 4 cases have been described in the literature. He records a fifth case, in a man of sixty-one, who had suffered a fracture of the femoral midshaft sixteen years previously. Because of malposition of the fragments, the femur had to be refractured soon after the accident, for correction of the alignment. Years later, varices began to form in the affected extremity, causing nocturnal pain and swelling of the foot after exertion. A phlebogram revealed a saccular aneurysm, the size of a hen's egg, in the femoral vein below the site of the old healed fracture deformity.

True aneurysms of veins must be differentiated from varicose veins and localized phlebectasias.

One roentgenogram.

ERNEST KRAFT, M.D.
Newington, Conn.

The Evaluation of a Method of Phlebography of the Lower Extremities. D. A. Felder and T. O. Murphy. *Surgery* 37: 198-205, February 1955.

This article on isoflow phlebography supplements a paper on the same subject appearing in *Radiology* (64: 852, 1955). The procedure differs from the one described in the earlier paper in that a larger amount of Diodrast is used, 80 c.c. instead of 40 c.c. This has resulted in a much higher percentage of visualization for the anterior tibial, deep femoral, and sural veins.

The application of such studies to the technic of a "flap operation" is discussed.

Four roentgenograms; 1 photograph.

THE DIGESTIVE SYSTEM

Gastric Carcinoma. A Statistical Review of 427 Cases of Carcinoma of the Stomach from 1941 through 1950. John R. Moore and H. S. Morton. *Ann. Surg.* 141: 185-192, February 1955.

This is a statistical review of 427 cases of carcinoma of the stomach seen from 1941 through 1950 in the Royal Victoria Hospital (Montreal). All the patients except one had symptoms of gastrointestinal disease. In order of frequency, the most common symptoms were loss of weight, abdominal pain and discomfort, and vomiting. Constipation was the chief complaint in 63 cases. A palpable mass was present in 120 (28 per cent), but this did not always indicate an inoperable growth. Free perforation occurred in 7 patients, all with advanced disease. There were no immediate deaths from this cause. Patients who had symptoms for more than one year showed the longest survival period.

Radiographic examination was the most valuable diagnostic procedure and revealed the lesion in 92 per cent of the cases. The operative rate was 81.7 per cent and was virtually the same during the first and second half of the period of study. Subtotal gastrectomy was done on 147 patients. There were 16 total gastrectomies, and the resectability rate was 38.2 per cent. Subtotal resection for cure was done in 81 instances, and subtotal resection for palliation in 66 cases. In the second five-year period there was an increase of 10 per cent in the palliative resections. Total gastrectomy was attended by a high operative mortality; the longest survival was three years. The overall five-year survival of 298 patients followed for a sufficient period was 11.7 per cent. There was a 37.5 per cent five-year survival in the group undergoing subtotal resections for cure, and 19.5 per cent five-year survival in the palliative group. The lymph nodes showed metastases in 34.3 per cent of the patients having resections for cure and 65.8 per cent of those having palliative resections. Of the patients with positive nodes, 10.6 per cent lived five years, while 36.7 per cent of those with negative nodes survived for that length of time.

Four tables. WYNTON H. CARROLL, M.D.
Shreveport, La.

Benign Gastric Polyps. David Niemetz and George K. Wharton. *Ann. Int. Med.* 42: 339-344, February 1955.

A review of 32 cases of benign gastric polyps seen at the Los Angeles County Hospital between 1943 and 1953 is presented. Of those studied histologically, all were adenomatous. None in the series showed malign

ant change. The greatest incidence was in the seventh and eighth decades.

Gastroscopy appeared to be superior to roentgen examination in the diagnosis. In only 3 of 23 patients did a gastrointestinal series afford a definite diagnosis of polyps. In 13 cases the diagnosis was simply "abnormal stomach." Gastroscopy, performed in 21 patients, gave a definite diagnosis of polyps in 15.

Symptoms are non-specific: abdominal pain, weight loss, and vomiting. Seven of the patients in this series had no symptoms referable to the digestive tract.

One roentgenogram; 3 photomicrographs; 3 tables.
G. J. WOOLHANDLER, M.D.
VA Center, Shreveport, La.

Perigastric Abscess. A Case Report with Preoperative Roentgen Diagnosis. M. M. Mehta. *Indian J. Radiol.* 9: 44-45, February 1955.

A young male of 24 years gave a six-month history of a gradually enlarging epigastric swelling. Physical examination showed general malnutrition and a firm, extremely tender mass, 3 X 3 inches, in the epigastrium. Preliminary fluoroscopy demonstrated a well localized epigastric collection of gas and fluid showing a horizontal fluid level with the patient upright. Barium passed readily into the stomach and then out through the lesser curvature of the gastric body into the previously noted cavity. The preoperative radiologic diagnosis was perforated gastric ulcer with perigastric abscess.

At surgery a large perigastric abscess was found measuring 4 inches across and 2½ inches deep. The abscess was adherent to the stomach, the under surface of the left lobe of the liver, the transverse colon, and the surrounding peritoneum. It contained mucoid material, blood, and some thick nodular tissue. Histopathological study indicated adenocarcinoma.

Two roentgenograms. JAMES W. BARBER, M.D.
Cheyenne, Wyo.

The X-Ray Delineation of Ingested Enteric-Coated Substances. Percy Barsky. *J. Pediat.* 46: 168-170, February 1955.

A case of ferrous gluconate ingestion in a 15-month-old boy is recorded. At least 40 enteric-coated "iron" tablets were swallowed by the child. These were identified on roentgenograms of the abdomen and subsequently removed by lavage of the stomach with an alkaline solution.

Two roentgenograms.
HOWARD L. STEINBACH, M.D.
University of California, S. F.

Intussusception: An Eight Year Survey. Grosvenor T. Root, Burt H. Christensen, and Carrell A. Peterson. *Surg., Gynec. & Obst.* 100: 171-174, February 1955.

An eight-year survey was carried out on all proved cases of intussusception seen at the Children's Hospital of the East Bay, Oakland, Calif. The total number of patients was 66, of whom two-thirds were boys. The majority were under two years of age; 43 were between the ages of three months and one year. In 6 cases the intussusception complicated an acute gastroenteritis.

The signs and symptoms in this series were: abdominal pain in 98 per cent, vomiting in 74 per cent, a palpable abdominal mass in 63 per cent, passage of blood by rectum in 60 per cent. Leukocytosis was observed in 80 per cent.

The relationship of duration of symptoms to the prognosis of the disease is a very direct one. Forty-four per cent of the patients had been having symptoms less than twenty-four hours and none of these required bowel resection. On the other hand, in one-fourth of those with symptoms of more than forty-eight hours duration, resection was necessary. The prognosis became more serious with advance of the intussusception to the left colon. In this group (15 cases) 20 per cent required bowel resection.

In order of frequency, the different types of intussusception found were as follows: ascending colon 38, ileosigmoid 10, transverse colon 7, small intestine 6, double 3, and ileorectal 2.

In 70 per cent of the cases x-ray examination was carried out. The plain films of the abdomen in nearly all instances demonstrated intestinal obstruction. However, it was the barium enema which proved to be most accurate, revealing the complete obstruction and the typical "coil spring" appearance. This examination was carried out on 27 patients, with a positive diagnosis in all cases. In 3 cases the barium enema completely reduced the intussusception. In 4 patients, in whom partial barium enema reduction occurred, the intussusception was completely gone at the time of surgery. As a rule, the barium enema was not used for therapeutic purposes, due to the necessity of establishing the viability of the bowel or associated structures.

There were 3 deaths in this series. Only 2 of these patients underwent surgery, with a resulting operative mortality for the series of 3 per cent.

One roentgenogram. ADAN PITOL, M.D.
University of Pennsylvania

Perforations of Respiratory and Alimentary Tracts by Metallic Foreign Bodies. W. B. Finerman. Arch. Otolaryng. 61: 164-166, February 1955.

The author reports a case of multiple metallic foreign bodies in the alimentary and respiratory tracts of a twelve-month-old Mexican child. Five open safety pins and approximately twelve needles were demonstrable on the initial roentgenogram. Ultimately, phonograph needles and safety pins were passed in the stool; other needles were extruded through the anterior and posterior chest walls and one through the anterior abdominal wall. Elective exploratory laparotomy permitted removal of a needle from the duodenum, but two from the chest wall and small bowel were not recovered during hospitalization.

Considering the size and character of the foreign material that passes safely, the author believes that foreign bodies in the respiratory and alimentary tracts, except for those in the trachea and larynx, do not warrant emergency surgery for removal. The case presented illustrates the basis for this concept.

Four roentgenograms. SUE L. NICKEY, M.D.
University of Texas, Dallas

Cholecystitis Glandularis Proliferans (Diverticula of the Gall-Bladder). L. Ian Burt and H. Masel. M. J. Australia 1: 270-272, Feb. 19, 1955.

Three cases of cholecystitis glandularis proliferans are presented. Various stages of this condition have been reported under such names as diverticula or diverticulosis, Rokitsky-Aschoff sinuses, Luschka's crypts, and chronic cholecystitis cystica.

Rokitsky-Aschoff sinuses are not uncommon findings at operation or autopsy, but relatively few cases

appear in the radiologic literature. This is probably because such gallbladders are diseased and concentration of the bile is impaired. With the use of the newer media, such as Telepaque, the condition is being found with greater frequency. The authors cite a number of descriptions of the radiologic findings. [A paper appearing more recently in Radiology tabulates these as reported by various observers (Ross, Finby, and Evans: Radiology 64: 366, 1955).—Ed.]

SHOZO IBA, M.D.
Downey, Calif.

Transduodenal Cholangiography. H. Gaylis and Kenneth Gunn. Surg., Gynec. & Obst. 100: 249-253, February 1955.

A new method of examination of the biliary tract is described. The portion of the duodenum containing the orifice of the bile duct is isolated by two rubber balloons on a lead-tipped catheter, and a radiopaque material of low viscosity (Pyelosil or diodone) is injected via the tube into this segment in an attempt to visualize the common duct and hepatic radicals by regurgitation.

A case study is presented of a 42-year-old man who had had biliary surgery on three previous occasions and presented a problem of differential diagnosis between primary hepatic and biliary disease. The common hepatic stump had been transplanted into the duodenum. Air insufflation outlined the ductal system and contrast material was injected according to the method described above, clearly outlining the biliary tree and revealing a stricture at the distal end of the common duct.

When this study was repeated on 5 normal patients no contrast material was shown by subsequent x-ray films to enter the ductal system, despite the use of anti-spasmodics. Studies were then done on segments removed *en bloc* from cadavers, but there was no regurgitation up the common duct of fluid injected under 600 mm. of water pressure.

Two anatomic features appeared to be responsible for failure of the procedure: (1) the oblique approach of the common bile duct as it passes through the duodenal wall; (2) a well marked mucosal flap overlying the duodenal papilla. Other factors, classed as neurogenic, are the sphincteric tone (sphincter of Oddi) and spasm of the circular muscle coat of the duodenum following distention.

The authors conclude that the procedure may be of use in cases where the common bile duct has been transplanted into the duodenum, where previous transduodenal sphincterotomy has been performed, and in the presence of spontaneous internal biliary fistulas.

Seven illustrations, including 4 roentgenograms.

HAROLD L. ATKINS, M.D.
University of Pennsylvania

Correlation of Surgical Pathology with Telepaque Cholecystography in Doses of Two Grams. Walter M. Whitehouse. Surg., Gynec. & Obst. 100: 211-215, February 1955.

The author notes that the ultimate test of any oral cholecystographic medium lies in the consistency with which it can predict the presence or absence of inflammatory disease or calculi in the gallbladder. He presents 124 cases in which operation followed study with Telepaque in doses of 2 gm. In all but 1, gallbladder abnormality was found as predicted by the study;

in the single exception an exploratory operation was carried out and, despite normal cholecystographic findings, chronic cholecystitis was found associated with a hamartoma of the liver. The other cases included 121 of cholecystitis, 1 of carcinoma of the bladder, 1 of gallbladder distention as a result of carcinoma of the pancreas.

In 50 cases (40.3 per cent) there was non-visualization of the gallbladder, and in 45 of these (90 per cent) stones were eventually found, 6 of which were radiopaque. The author points out that a non-functioning gallbladder, confirmed by a second examination, is definitely indicative of biliary tract disease.

In 23 of 27 cases showing faint visualization, stones were found to be present. In 21 these were demonstrated roentgenographically.

In 44 cases visualization was good, and stones were apparent in 42 of these. One patient showed a polyp and 1 was felt to be normal but was later found to have chronic cholecystitis. The point is made that the normally concentrating gallbladder may be diseased. In 3 cases in which there were stones, there was excellent concentration of the medium.

The author again stresses the fact that the pathological changes do not absolutely mirror the variation in density of the gallbladder shadow, and it is only the presence of stones that leads one to suspect disease in the normally concentrating gallbladder. He also feels that there is no need to use more than the usual dose of medium in confirmatory tests.

Two tables.

A. EDWARD O'HARA, M.D.
University of Pennsylvania

A Fat Absorption Test Using Iodized Oil, with Particular Application as a Screening Test in the Diagnosis of Fibrocystic Disease of the Pancreas. Frederic N. Silverman and Harry C. Shirkey. *Pediatrics* 15: 143-148, February 1955.

The authors describe a test used in the diagnosis of fibrocystic disease of the pancreas. Though it involves no radiographic procedures, it does employ a medium used chiefly in roentgenology, Lipiodol. From 5 to 10 c.c., depending on body weight, are given by mouth or stomach tube. Urine samples are then collected, serially diluted, and tested qualitatively for iodine. Forty-nine children with normal pancreatic function all gave positive tests for iodine in dilutions of from 1:4 to 1:32, while none of 13 with fibrocystic disease showed positive tests in dilution higher than 1:2. The test is not specific, since diarrhea and debility from other acute or chronic illnesses, by interfering with absorption or causing temporary suppression of pancreatic secretion, can also give results indicating absence or impairment of the secretion of lipase.

One chart; 1 table.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

HERNIA

A Case of Incarcerated Diaphragmatic Hernia. Katharine Branson. *Ann. Surg.* 141: 273-275, February 1955.

A 68-year-old white female gave a history of an attack of gastritis eleven months earlier. Vomiting had recurred at frequent intervals with no definite relation to meals. Radiographic examination revealed a large left diaphragmatic hernia through an opening 2 inches lateral to the hiatus, with marked irritability at the

lower end of the esophagus which it was thought might be due to contraction of the diaphragm rather than to true esophageal spasm. In view of these observations, crushing of the left phrenic nerve was done, as the patient was not in condition for any other type of surgery. She made a satisfactory recovery and gained weight, but the roentgen findings showed little change.

On emergency admission a year later, for persistent vomiting, it was impossible to demonstrate the normal contour of the stomach or to get any barium through the diaphragm into the hernia, although previous films had shown the fundus of the stomach in the hernial sac. Repeat examination twenty-four hours later showed the barium apparently lying in the two extremities of an inverted U. At surgery the stomach was found incarcerated in the diaphragmatic hernia, but the lesser curvature had remained below the diaphragm and provided a passage by which the food could pass into the pylorus. Symptoms of complete obstruction supervened whenever the lesser curvature slipped through the hiatus. The incarcerated stomach was removed from the hernial sac and stitched along the under surface of the diaphragm. The patient left the hospital in twenty-three days, feeling well on a full diet.

Four roentgenograms.

WYNTON H. CARROLL, M.D.
Shreveport, La.

THE MUSCULOSKELETAL SYSTEM

Familial Osteochondritis Dissecans. M. Pickering Pick. *J. Bone & Joint Surg.* 37-B: 142-145, February 1955.

The cases described here are those of a mother and 3 daughters, all of whom suffered from osteochondritis dissecans. The mother, aged forty, gave a history of recurrent swelling of the knees during her 'teens, and said that both knees used to let her down. In recent years she had suffered from "rheumatism." She was only 4 feet 6 inches in height, and the children were about 6 inches below the normal height for their ages. In other respects, they were normally developed. Loose bodies were removed from the knees of the oldest daughter and from the right elbow of the second daughter. The third daughter, aged ten, had no symptoms but roentgenograms revealed typical changes of osteochondritis dissecans in both medial femoral condyles. A fourth daughter had no evidence of the disease.

The occurrence of osteochondritis dissecans in more than one member of a family is unusual. The fact that it does sometimes occur lends weight to the suggestion that in many of these cases, especially when more than one joint is involved, there is an underlying constitutional or developmental factor.

Eight roentgenograms.

JOSEPH P. TOMSULA, M.D.
Baton Rouge, La.

Osteochondritis Dissecans in Three Members of One Family. T. B. Gardiner. *J. Bone & Joint Surg.* 37-B: 139-141, February 1955.

Osteochondritis dissecans affecting a single joint is relatively common. Multiple lesions are less common, and the occurrence of osteochondritis dissecans in several members of a family is rare.

This report refers to a family of 3 boys and a girl. One boy, nineteen years of age, showed osteochondritis dissecans of the medial femoral condyles of both knees.

Surgery was done on the left knee. One and a half years later limitation of flexion was still present bilaterally. The sister, two years younger than the first patient, was also seen at the age of nineteen and osteochondritis dissecans of the left medial femoral condyle was identified. The fragment was removed. Eighteen months after surgery there were no complaints. A younger brother was seen at the age of eighteen years. He had bilateral osteochondritis dissecans of the medial femoral condyles.

A third brother, the mother, and the father were examined but none showed evidence of the disease.

Four roentgenograms; 2 photographs.

JOSEPH P. TOMSULA, M.D.
Baton Rouge, La.

Osteoarthritis of the Hip. A Study of the Clinical Pathology. G. C. Lloyd-Roberts. *J. Bone & Joint Surg.* 37-B: 8-47, February 1955.

This is an excellent thirty-seven page abstract of a prize winning essay delivered in 1953. The scope of the work, including case presentation and discussion, enables the author to corroborate prior studies by other authors and to refute some hypotheses previously advanced. Since any attempt at a short abstract would be an injustice the author's summary is quoted:

"1. The capsular changes in osteoarthritis of the hip and their pathogenesis are described, and it is concluded that symptoms are due mainly to this abnormality.

"2. The clinical significance and pathogenesis of subchondral sclerosis, cysts, osteophytes, secondary subluxation and new bone formation on the lower border of the femoral neck are discussed.

"3. These bony features which can be seen in the radiograph may, under certain circumstances, be correlated with the symptoms.

"4. The influence of joint debris and capsular fibrosis upon the symptoms arising in other osteoarthritic joints is considered.

"5. The mechanism by which osteoarthritis develops in hip joints with an anatomical abnormality is discussed in relation to the normal functional anatomy of the hip.

"6. The evolution of osteoarthritis in dysplasia of the hip is considered with special reference to its diagnosis, prognosis, and early treatment.

"7. The supposition that osteoarthritis is commonly due to progressive ischaemia in the femoral head has been investigated and is rejected.

"8. The cause of idiopathic osteoarthritis remains obscure but the evidence suggests that constitutional rather than local conditions in the joint account for many of these cases."

All of the above points are thoroughly examined. Every radiologist should become acquainted with the material presented because of the excellent summation of the problems concerned in an adequate interpretation of osteoarthritis involving the hip.

Seventy-nine figures, including 36 roentgenograms and 11 radiomicrographs.

JOSEPH P. TOMSULA, M.D.
Baton Rouge, La.

The Fate of Radiopaque Media Injected into the Cancellous Bone of the Extremities. R. G. Harrison and H. H. Gossman. *J. Bone & Joint Surg.* 37-B: 150-156, February 1955.

Observations were made on 6 cadavers following

the injection of a radiopaque medium directly into cancellous bone. The experiments were performed forty-eight to seventy-two hours after death. Lipiodol was at first used as the contrast medium, but it was later found that 50 per cent diodone could be introduced more easily, because of its lower viscosity. Subsequently a suspension of barium sulfate was found to provide better contrast, though the pressure necessary for injection was slightly greater than with diodone.

These researches confirm those of previous workers in demonstrating the rapidity of drainage into the venous system of solutions and suspensions introduced into cancellous bone. In the living subject, diodone introduced into the greater trochanter passes into the regional veins within half a minute and is completely removed from these veins within three to four minutes.

The method of introduction of solutions and suspensions into cancellous bone is also of interest for the technic of phlebography. Apart from the studies of continental (European) workers, this procedure appears not to be generally recognized, although it is easily effected. The experiments here reported suggest that the venous system of a limb may be filled easily and safely through a needle inserted into cancellous bone at numerous sites. The simplicity and safety of the procedure, and the fact that it can be used in edematous limbs in which the superficial veins are not visible, further justify its clinical application. The danger of osteomyelitis after transfusion into the medullary cavity of infants must, however, be remembered.

Eight roentgenograms.

JOSEPH P. TOMSULA, M.D.
Baton Rouge, La.

The Necessity for Water-Soluble Contrast Media for Lumbar Myelography. H. Koberg. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 82: 236-243, February 1955. (In German)

Iodized oils, which are commonly used for lumbar myelography, are irritating and lead to adhesions if not fully removed after the examination. They frequently fail to coat the nerve sheaths and are safe only in amounts which are insufficient for detailed studies. Aqueous solutions, on the other hand, are able to reach into the smallest recesses and demonstrate the finest details of the nerve sheaths. They are contraindicated, however, in diseases of the kidneys and of the cardiovascular system. Nor can they be used for thoracic or cervical myelography since spinal anesthesia is required in these cases.

The author states that in a series of 300 cases he has seen no permanent or delayed damage, and that a correct diagnosis has been made in 95 per cent of the cases, preoperatively.

Since accuracy and dependability of lumbar myelographic diagnosis have been greatly improved with the aid of water-soluble contrast media, surgical explorations of single and multiple disk lesions have become simplified to a considerable extent.

Twelve roentgenograms. ERNEST KRAFT, M.D.
Newington, Conn.

THE SPINAL CORD

Diastematomyelia. Colin B. Holman, Hendrik J. Svien, William H. Bickel, and Haddow M. Keith. *Pediatrics* 15: 191-194, February 1955.

Diastematomyelia is a congenital transfixion of the

spinal cord by a sagittal bony or fibrocartilaginous spicule which extends from the anterior to the posterior wall of the spinal canal. Since the caudal end of the cord normally migrates upward by reason of disproportionate growth, the fixation by the spicule results in stretching and consequent degeneration of the cord, with progressive neurological changes. Confirmation of the diagnosis of diastematomyelia depends on the roentgenologic criteria assembled by Neuhauser and co-workers (*Radiology* 54: 659, 1950). Myelography shows a filling defect in the opaque column in the region of the mid-line septum. Immediate surgery is indicated to halt the progression of the disease.

A single case is presented in which the diagnosis was made at the age of eight. The patient gave a history of increasing scoliosis for five years and slight weakness of the right leg. Plain films showed moderately severe scoliosis centered at D9, widening of the neural canal in the lower thoracic and lumbar areas, and anomalous formation of the neural arches of the upper three lumbar vertebrae. Myelography showed the characteristic diamond-shaped defect dividing the canal at L1, with a tiny bone spicule visible in the center of the defect. The transfixing spur was removed surgically, and eleven months later a fusion was done for the scoliosis. No increase in the neurologic deficit occurred.

Two roentgenograms; 1 photograph; 1 drawing.
ZAC F. ENDRESS, M.D.
Pontiac, Mich.

GYNECOLOGY AND OBSTETRICS

An Assessment of the Value of Antenatal Radiological Pelvimetry Based on 500 Successive Pelvimetric Examinations. G. W. Pimblett and T. G. E. White. *J. Obst. & Gynaec. Brit. Emp.* 62: 17-28, February 1955.

The authors analyzed a series of 500 radiological pelvimetries to determine the value of this procedure in forecasting the course of labor in suspected cases of cephalopelvic disproportion. The techniques of pelvimetry and cephalometry utilized and the methods of analysis are discussed in detail. The radiological predictions were made on the basis of Moir's charts, but it is stressed that these charts do not constitute a complete report and that other factors shown on the radiograph must be considered. The patients were placed in 3 prognostic groups:

- No disproportion: Likely mode of delivery, spontaneous.
- Definite disproportion: Difficult spontaneous or forceps delivery.
- Severe disproportion: Vaginal delivery even with forceps unlikely. Cesarean section probable.

Results of this study show the predictions based on the authors' methods to be reliable. In 97 per cent of assessable cases, a correct forecast was given.

Four roentgenograms; 5 charts; 7 tables.

THEODORE E. KEATS, M.D.
University of California, S. F.

Gas in Fetal Circulation—A Sign of Fetal Death. Case Report. Edwin A. Riemenschneider. *Ohio State M. J.* 51: 139, February 1955.

A single case is reported of fetal death confirmed be-

fore delivery by roentgen demonstration of gas in the circulation. It is felt that this finding occurs frequently and should be kept in mind whenever the question whether or not the fetus is alive arises.

One roentgenogram.

THE GENITOURINARY SYSTEM

Hypaque: An Improved Medium for Excretory Urography. A Preliminary Report of 210 Cases. Thomas D. Moore and Raymond F. Mayer. *South. M. J.* 48: 135-140, February 1955.

The new urographic medium, Hypaque, contains 59.87 per cent iodine in a 50 per cent solution and is highly water-soluble. It is excreted almost entirely through the kidneys following intravenous administration; most of the drug is eliminated within two hours, and over 90 per cent within twenty-four hours. The authors have used this medium in 210 successive patients (99 males, 111 females) ranging in age from five to ninety years. A laxative (2 gm. of compound licorice powder and heavy magnesium oxide stirred in half a glass of water) is usually given the night before urography is contemplated. Fluids are withheld for about twelve hours prior to the examination. Each patient is questioned carefully concerning allergy or sensitivity, particularly to radiographic media. Sensitivity tests consist routinely in the injection of 50 per cent Hypaque, 0.1 c.c. intradermally and 1.0 c.c. intravenously, prior to the administration of the full diagnostic dose. Better roentgenograms are obtained when two to four minutes are taken to inject 30 c.c. of Hypaque. With three minutes as the optimum time for injection, side reactions are virtually absent. Compression is used routinely. Films are examined during processing to determine the spacing of further exposures.

The quality of the excretory urograms obtained with Hypaque was excellent in the authors' series, with 195 (92.9 per cent) considered satisfactory for diagnostic purposes. Twenty-eight patients (13.3 per cent) experienced mild reactions, including nausea, vomiting, excessive salivation, flushing, dizziness, urticaria, and muscular twitching. The majority of these reactions occurred when the medium was injected too rapidly. The complete absence of vein cramp was notable. There were virtually no vasomotor reactions, and none of the patients complained of the bitter (metallic) taste encountered with some other excretory media.

Ten roentgenograms; 3 tables.

Further Experiences in Aortography. Ian F. Potts. *M. J. Australia* 1: 232-233, Feb. 12, 1955.

This is a brief note supplementing an earlier account of the author's experience with translumbar aortography (*M. J. Australia* 1: 173, 1954. *Abst. in Radiology* 63: 780, 1954). It includes reports of 7 cases in which aortography was performed. Urokon (70 per cent) is the contrast agent of choice. Extravasation of the medium may occur as a result of (1) movement of the needle during its connection to the tubing; (2) "whip-lash" effect due to high pressure during the injection; (3) spasm of the vessel causing the wall to retreat from the needle point. Pain of twelve to twenty-four hours duration may follow extravasation. It may also occur as a result of periaortic hematoma due to multiple punctures.

In a series of nearly 100 examinations there had been no mortality, "scares," or real morbidity. The pro-

cedure was found useful for studying renal and extrarenal masses, aberrant vessels, renal function, and hydronephrosis. Hyperplasia and adrenal tumors are better studied by perirenal air injection.

Five roentgenograms.

PAUL MASSIK, M.D.
Quincy, Mass.

Nephrocalcinosis Visible by X-Ray Associated with Chronic Glomerulonephritis. Walter L. Arons, W. R. Christensen, and M. C. Sosman. *Ann. Int. Med.* 42: 260-282, February 1955.

The authors describe 4 cases of nephrocalcinosis associated with glomerulonephritis (2 confirmed at autopsy) and seek to differentiate the roentgen findings from those in nephrocalcinosis associated with other conditions. In 3 of the cases the calcification, as demonstrated roentgenologically, was largely confined to the renal cortex; in the fourth case the deposits were diffusely distributed throughout the kidney but proved on histologic examination to be chiefly cortical.

Nephrocalcinosis occurs also in hyperparathyroidism, hyperchloremic acidosis, vitamin D intoxication, sarcoidosis, and neoplastic bone destruction, in all of which there is an increased excretion of calcium, but in such cases the calcium deposits are seen mainly in the medullary pyramids.

Although the association of nephrocalcinosis with glomerulonephritis is uncommon, it appears obvious that the x-ray study may be important in arriving at a logical diagnosis. In 3 of the authors' cases and in 2 previously reported, excessive calcium intake in the form of milk appeared to be a factor.

Five roentgenograms; 2 photomicrographs; 1 table.

WILLIAM SNOW, M.D.
VA Center, Shreveport, La.

Obstruction of the Renal Artery Producing Malignant Hypertension. Irving Imber and Robert H. Clymer, Jr. *New England J. Med.* 252: 301-304, Feb. 24, 1955.

Reports have appeared of unilateral renal lesions producing hypertension which was cured by nephrectomy. In the case recorded here malignant hypertension was due to an extrinsic compression of the right renal artery. The arterial obstruction was demonstrated by aortography, and a right nephrectomy resulted in correction of severe functional impairment of the contralateral kidney.

A 34-year-old man complaining of head pain, fatigue, nausea and vomiting, and weight loss had a blood pressure of 195/130 and hypertensive retinopathy. The retrograde pyelogram showed morphologically normal right and left kidneys. On intravenous urography, however, the right kidney was poorly visualized until the one-hour film. An aortogram showed a normal left renal artery and normal blood supply to the left kidney, but the right renal artery was deformed at the hilus of the kidney, with constriction of the lumen. Despite bilaterally diminished renal function, removal of the offending kidney effected a cure of the hypertensive state. Pathologic examination showed no disease in the resected kidney. A band of fibrous tissue surrounded the artery. By disclosing the vascular abnormality in the renal arterial tree, abdominal aortography proved to be of great value in this situation.

Three roentgenograms; 1 diagram.

DONALD DEF. BAUER, M.D.
Coos Bay, Ore.

MISCELLANEOUS

Roentgenologic Findings in Diffuse Scleroderma. E. Goetsch. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 82: 247-250, February 1955. (In German)

Associated with diffuse scleroderma are roentgenologic changes in the skeleton, soft tissues, blood vessels, lungs, esophagus, stomach, and intestine. Marie-Strümpell spondylitis is occasionally found.

A single case is reported in a female, aged 52, with a twenty-year history of dizziness and swelling as well as numbness of the finger tips. For the past eight to ten years the finger tips had been stiff and foreshortened. For two years the facial skin had been so tense and stiff that the mouth could barely be opened. The wrists were swollen and discharged chalky material dorsally, and there was progressive constipation. The patient had been unable to work for ten years and for six years had been a complete invalid.

Roentgenologically, there was typical acro-osteolysis of the distal phalanges, marked spotty calcium deposits in the dorsal aspect of either wrist, interstitial pneumonitis, especially of the right lower lobe, and bilateral basal pleural thickening. The esophagus was atonic, showing absence of peristalsis and of mucosal pattern and presence of stenosis in the region of the cardia, with a thirty-hour barium residue. There was diminished peristalsis in the stomach, the duodenum, and upper jejunum, with delayed emptying. The duodenum and upper jejunum showed atonicity and dilatation. There was also marked fecal stasis in the colon, with a seven-day barium residue.

The patient died soon after examination, with signs of acute enteritis and cerebral hemorrhage.

Three roentgenograms. ERNEST KRAFT, M.D.
Newington, Conn.

Scleroderma. Pulmonary and Skin Studies Before and After Treatment with Cortisone. A. Salomon, B. Appel, E. F. Dougherty, J. A. Herschfus, and M. S. Segal. *Arch. Int. Med.* 95: 103-111, January 1955.

Three patients with generalized scleroderma with pulmonary involvement received cortisone orally. Pulmonary function and ventilation studies as well as roentgenograms and skin biopsies were made before and after treatment. A total dose of 4.6 gm. was given over a period of thirty-five days.

Varied objective and subjective improvement was noted. The skin lesions appeared to be more responsive than those in the lungs. The diffuse pulmonary involvement demonstrated roentgenographically was unchanged. Relapse after four to six months occurred in all 3 patients. The pulmonary function showed no significant effect of treatment.

The pathology and roentgen appearance of pulmonary involvement in generalized scleroderma are briefly correlated with the altered respiratory and ventilation function studies.

Three roentgenograms; 3 photomicrographs.

ALBERT R. BENNETT, M.D.
Mt. Sinai Hospital, Cleveland

The "In Vivo" Dissolution of Metastatic Calcium. An Approach to Atherosclerosis. Norman E. Clarke, Charles N. Clarke, and Robert E. Mosher. *Am. J. M. Sc.* 229: 142-149, February 1955.

The chelating compound ethylene diamine tetraacetic acid (EDTA) was used by the authors in an ef-

fort to remove metastatic calcium from the human body. EDTA has the ability to form strong soluble complexes with cations in solution. It is not metabolized in the body and is excreted entirely in the urine. These two properties permit the removal of calcium from the serum, and the rather prompt restoration of the serum calcium levels that was observed is presumably the result of mobilization of calcium from areas of metastatic deposition. Dissolution of these ectopic calcific deposits may thus be effected.

EDTA was administered in a solution of 5 gm. to 500 c.c. of 5 per cent glucose or normal saline over a period of an hour and a half to three hours to 22 patients. The principal untoward side-effects were burning above the site of infusion, mild nausea, and occasionally diarrhea. Five patients showed toxic reactions manifested by an erythematous scaly dermatitis. One patient exhibited small bullous eruptions on the oral mucous membranes of sufficient severity that the treatment had to be discontinued. Most of the toxic reactions could be controlled with pyridoxine, and manifestations subsided rapidly when therapy was terminated.

One case of extensive bilateral nephrocalcinosis treated in this manner is described. Roentgenographically, the patient showed progressive calcific deposition in the renal parenchyma until the institution of EDTA therapy. A roentgenogram made two weeks after 500 gm. of EDTA had been administered showed at least 50 to 65 per cent of the calcium to have been removed from the kidneys. The patient, whose hearing had been impaired for several years, also showed a striking objective and subjective improvement in auditory acuity, and complete relief of pre-existing ulcer symptoms was obtained.

Owing to the supposed interrelationship of cholesterol and calcium metabolism and to the parallelism of calcific and cholesterol deposits in the aortic wall in experimental animals, it is hoped that a chelating agent which can safely remove metastatic calcium may in turn remove cholesterol deposits from arterial walls. Thus, a possible therapeutic approach to atherosclerosis is envisaged.

Three roentgenograms; 2 tables.

B. J. PARNELL, M.D.
University of Texas, Dallas

TECHNIC

The Principles of the Construction and Function of the Stereo-Pantograph. A Device for Stereoscopic Pantomography with a Single Exposure. Yrjö V. Paatero. *Acta radiol* 43: 113-119, February 1955.

The author has published a number of earlier reports on "pantomography," a procedure which he has developed for the purpose of obtaining stereoscopic studies of curved surfaces on flat films (see, for example, *Acta radiol* 41: 321, 1954. *Abst. in Radiology* 64: 307, 1955). In this paper he describes the construction of the device and its operation. Two narrow roentgen beams pass through an apparatus holding the rotating patient. Simultaneously two cassettes move past the narrow beams at the same linear velocity at which the patient is rotating. At any given moment the part being radiographed is stationary in respect to the film

being exposed through the narrow slit in the lead facing in front of the cassettes.

Two roentgenograms; 3 drawings.

RICHARD E. OTTOMAN, M.D.
University of California, L. A.

Pin-Hole Autoradiography. Erik Odeblad. *Acta radiol* 43: 145-151, February 1955.

Elaboration of methods for good focusing of radiations from radioactive isotopes is needed; and until such can be attained, dependence must be placed upon the pinhole camera. By this means, images of the distribution of radioactive isotopes in various applicators may be obtained. Pinhole autoradiography also permits study of distribution of therapeutically administered radioisotopes in animal experimentation.

The principles of construction and properties of the pinhole camera as used in autoradiography are outlined in this paper. It appears from the discussion that the fields of usefulness are limited. Specific applications are to be published later, along with additional discussion on focusing and collimation methods.

Four figures; 1 table.

DON E. MATTHIASEN, M.D.
Phoenix, Ariz.

The Specification of Roentgen Ray Output and Quality. R. F. Farr. *Acta radiol* 43: 152-160, February 1955.

Differences in output of a given roentgen-ray tube will be noted when conditions under which measurements are made are inconstant. The half-value layer will also vary with changes in the conditions under which quality determinations are made. It is this which accounts for discrepancies in the reports of manufacturers and practicing radiologists on the same equipment. Beam width, type of applicator or cone, and distances between target, filter, and ionization chamber all affect output and quality measurements. Of particular importance is explicit specification of conditions for half-value layer measurements, since these are essential in comparing depth doses, whereas output measurements are of concern only in comparing performances of different machines.

Studies by the author reveal that the apparent h.v.l. increases with the area of the beam employed. Ideally, the beam width should be limited to cover the chamber, free of penumbra. Also, the h.v.l. increases as the target-filter distance is decreased, or as the filter-ionization chamber distance decreases. The filter carrier in most machines is too close to the target. The chamber and filter should be so disposed that the filter scatters no radiation into the chamber. If the chamber is 50 cm. from the target and the filters are placed 20 to 30 cm. from either, the measured h.v.l. will, for practical purposes, be the true one.

The standardization of tube output measurements should include the use of a greater field width than for quality determinations. The universal use of a 10-cm. circular applicator at 50-cm. focus distance would be convenient. Measurement with closed-end applicators should be made at 20.7 cm. from the end of the cone. Multiplying the result by 2 will give the effective value at 50 cm.

Five tables.

DON E. MATTHIASEN, M.D.
Phoenix, Ariz.

RADIOTHERAPY

The Treatment of Malignant Melanomas. Heribert Müller-Miny. *Strahlentherapie* 96: 310-312, February 1955.

The results of treatment of malignant melanoma at fourteen roentgen and radium institutes were compiled by the Rheinisch-Westfalian Roentgen Society. The number of treated cases was 231, of which 147 were treated solely by irradiation, while 84 had some kind of operative procedure prior to irradiation, such as diagnostic excision or electrocoagulation. Of the latter group, only 2 were known to have survived for three years (1 of these for five years). Of the 147 patients receiving irradiation alone, 6 died of metastases, 1 intercurrently; 138 were still alive, 67 of whom had been treated before December 1950.

JUERGEN L. SCHAPIRO, M.D.
Ohio State University

Malignant Lymphoma: Radiological Aspects. K. M. Rai. *Indian J. Radiol.* 9: 22-30, February 1955.

In the years 1950-53, 214 patients with malignant lymphoma were referred to the Barnard Institute of Radiology, Madras, India, for treatment, constituting 2.5 per cent of the total number of cancer patients seen in that period. Sharply localized disease is treated radically with large fields and a calculated tumor dose of 3,500 to 4,000 r in three weeks. In more extensive disease, in which a single area and its related deep lymph nodes are involved, treatment is less vigorous, but an attempt is made to deliver about 3,500 r in three weeks to the center of the tumor area. For widely disseminated lesions, a "chasing" technic is employed: the dose is kept well within tolerance limits and is repeated as new foci appear. The author also discusses the use of nitrogen mustards and outlines a technic which is essentially the same as that generally employed. He believes patients with superior mediastinal lymphomatous masses and impaired respiration or circulation are better managed by nitrogen mustards than by deep roentgen therapy.

Of 62 patients with Hodgkin's disease, 60 per cent showed "remarkable improvement"; almost all of the others were benefited to some degree. Treatment of 123 cases of lymphosarcoma resulted in approximately 50 per cent "satisfactory regressions." Satisfactory results were also obtained in 65 per cent of 21 patients having reticulum-cell sarcoma.

Two cases are reported in detail: one of generalized lymphoma (type unstated) managed successfully over a period of three years by the "chasing" technic, and a second case of widespread cervical and thoracic lymphoma (type unstated) with a three-year survival following roentgen therapy.

This report does not present any new material. The conclusions are merely that roentgen therapy is helpful in the large majority of cases of malignant lymphoma.

Five roentgenograms; 1 drawing.

JAMES W. BARBER, M.D.
Cheyenne, Wyo.

Problems in the Therapy of Breast Cancer. R. Wanke. *Strahlentherapie* 96: 279-285, February 1955.

The author gives a statistical evaluation of the results of treatment (radical mastectomy with postoperative radiation therapy to the regional lymph nodes) in

45,000 cases of mammary cancer, which were analyzed with the assistance of the Bureau of Statistics of the State of Schleswig-Holstein. He foresees further improvement of results with the use of preoperative irradiation, provided tumor doses are given.

The internal mammary chain was found to be involved in 10 to 15 per cent of clinical Stage I cases (approximately twice as often when the primary lesion was centrally located as when it was situated laterally) and in 30 to 50 per cent of cases with axillary involvement. Supraclavicular nodes were involved in 22.6 per cent of cases. An improvement in treatment results is to be expected from extension of the radical operation for removal of the homolateral internal mammary chain only in Stage I cases. The highest incidence was found to be at forty-eight years, which is in line with the general rise of cancer incidence in older groups. Evaluation of 10,160 cases showed that five-year survival results are not poorer for women under forty-five years. Excluding all Stage III and IV cases, the five-year survival rate for women under forty-five was 57 per cent and for women over forty-five, 48 per cent (the statistical error being larger for the younger age group because of the smaller number of cases).

A little over 2 per cent of the cases occurred during pregnancy or lactation. The five-year survival for such patients, as determined by Wanke and Sattelmacher, was 26 per cent (± 2 per cent).

These latter authors have given the ratio of bilateral mammary cancer to unilateral involvement as 806 to 22,518, or 3.97 per cent; 17.6 per cent of the bilateral tumors appeared simultaneously in both breasts. The five-year survival rate for bilateral cases from the literature and the author's own clinics was 43.2 per cent following the second operation. The figures for the entire series are as follows:

Five-year survival without treatment.....	13%
Ten-year survival without treatment.....	4%
Five-year survival with radical mastectomy and postoperative radiation.....	47%
Ten-year survival with radical mastectomy and postoperative radiation.....	23-30%
Five-year survival with radical mastectomy alone.....	35%
Five-year survival with radical mastectomy alone in Stage I.....	70%
Ten-year survival with radical mastectomy alone in Stage I.....	49-4%

The paper concludes with a brief consideration of hormone therapy.

Two graphs. JUERGEN L. SCHAPIRO, M.D.
Ohio State University

The Curability of Regional Lymph Node Metastases in Cancer of the Uterine Cervix. John B. Graham and Ruth M. Graham. *Surg., Gynec. & Obst.* 100: 149-155, February 1955.

The regional lymph nodes are of critical importance in cancer of the cervix uteri. If they are involved, the chance for survival is thought to be materially reduced. Until recently the only data available have referred to the results of surgical treatment, but some recent evidence suggests that radiotherapy does control node metastases in a number of patients.

The authors feel the vaginal smear may aid in deter-

mining not only which patients in Stages I and II may have regional node metastases but also which cases will have the best chance to profit by radiotherapy. In some patients the basal cells of the vaginal epithelium show a characteristic reaction that is called the sensitization response (SR). This response and, to a less extent, the presence of numerous basal cells in the vaginal epithelium are poorly understood phenomena that seem to indicate a favorably receptive state for radiotherapy and at the same time a rather high incidence of regional node involvement. It is postulated that SR is an index of host-resistance and that radiotherapy, while this is active, is most effective.

The fact that lymph node metastases respond favorably to irradiation in one situation should not lead one to believe that they are always easily controlled. SR is apparently not elicited by the earliest tumors that are still relatively benign, but, when the tumor becomes moderately advanced, it does appear. It is, however, transitory, and when it is lost the patient passes into a phase of radiation refractoriness in which node involvement may steadily increase and be entirely impervious to irradiation.

In conclusion, the authors state that the effectiveness of radiotherapy for uterine cervical cancer which has metastasized to the regional nodes is a good deal more difficult to evaluate than the results of surgery, but the evidence suggests that it may be superior to surgery in selected cases.

Four tables.

HENRY P. PENDERGRASS, M.D.
University of Pennsylvania

Carcinoma of the Cervical Stump. J. R. Dodds and J. P. A. Latour. *Am. J. Obst. & Gynec.* **69**: 252-255, February 1955.

The authors have reviewed 997 cases of carcinoma of the cervix seen at the Royal Victoria Montreal Maternity Hospital between 1926 and 1953, including 75 cases of carcinoma in the residual cervix. Their conclusion is that carcinoma of the cervical stump is not significantly different from other cervical cancers in any respect except for the method of treatment. The cervical stump should have the same vault dose of radium as carcinoma of the cervix with the uterus present and a canal dose proportional to the residual length. In this way, approximately 60 to 70 per cent of the standard dose can be used. The standard dose of external radiation is then given. The results for cases treated between 1939 and 1948, when a more adequate dosage of radiation was used, compared favorably with those obtained in the treatment of carcinoma of the cervix with the whole uterus present. The complications were not significantly higher than in non-stump cases.

Six tables.

R. L. EGAN, M.D.
M. D. Anderson Hospital, Houston

Radium Menopause or Hysterectomy. Part I. The Effects of the Radiation Menopause—A Controlled Study. A. C. Turnbull. *J. Obst. & Gynaec. Brit. Emp.* **62**: 176-186, April 1955.

This study was conducted to analyze statistically the symptoms of the menopause induced by radiation as opposed to a natural menopause. The incidence and severity of flushing and sweating, emotional instability, loss of sexual desire, dyspareunia, and vaginal discharge were considered. One hundred and fifty-seven women were studied, 101 in whom the menopause was induced by radium or x-rays and 56 who had experienced

a natural menopause. The two groups were comparable as to age, parity, and marital status.

Flushing was of approximately the same severity in the irradiated patients and those experiencing a natural menopause. Its incidence was found to decrease with increase in age at the time of the menopause and to be greater in women of low parity than in those of higher parity. Those who had premenopausal flushing of a moderate or severe degree showed more severe symptoms following the menopause, but no significant difference in the treated and control cases was noted. Hormonal imbalance as indicated clinically did not show any relationship to the severity of flushing after either type of menopause.

An analysis of emotional instability (for which fairly critical criteria were set up) illustrated a greater incidence of premenopausal emotional disturbance in the group treated with radiation but less depression after the menopause than in those patients of the control group.

Loss of sexual desire occurred in 60 per cent of the women before the menopause; of the remainder, 50 per cent had a diminished sexual urge after the menopause whether this was natural or artificially induced. The incidence of dyspareunia was not statistically different in the treated and untreated cases. Vaginal discharge was more often cured in the patients treated with radiation than those experiencing a natural menopause. In the irradiated group, however, vaginal discharge tended to occur more frequently than in those with a natural menopause. The author considers this a very minor problem, however.

It is concluded that the decision to treat irregular bleeding in women over forty years of age should not be based upon any of the subjective or objective symptoms listed above, since there was practically no difference in the groups treated by radiation and those permitted a natural menopause. The determining factors should be the reliability of the method, operative risk and operative morbidity, and the possible danger of neoplastic development. In the author's experience induction of the menopause by irradiation is safer than hysterectomy and has been found simple and effective.

Twelve tables.

JOHN W. WILSON, M.D.
University of Texas, Dallas

Radiation Therapy in Retroperitoneal Tumors. Wm. E. Costolow and Wm. R. Wisdom. *Arch. Surg.* **70**: 199-202, February 1955.

Experience in the treatment of retroperitoneal tumors, including renal tumors, over a twenty-three-year period is the basis for this report. Fifty-two renal tumors were treated, of which 36 were adenocarcinomas. The tumor dose for this latter group averaged 2,200 r in thirty-two days. Although the disease was seen in various stages, often with postoperative recurrences, 2 patients survived five years. Ten cases of Wilms' tumor were treated with a similar dose, including 4 with pulmonary metastases, and 1 patient is alive and well after twelve years.

During this period 10 patients with primary retroperitoneal tumors were treated, receiving tumor doses ranging from 2,500 r in nineteen days to 5,200 r in fifty-three days. There were two survivals of more than a year: 1 patient with myxosarcomatous degeneration of a lipoma survived five years; another, with undifferentiated sarcoma, survived seven years.

Eighty-two cases of lymphosarcoma are included in

the series. Eleven patients had a retroperitoneal mass with no evidence of peripheral disease and in this group excellent palliation was obtained. One patient lived four years, and another ten years.

In extensive retroperitoneal tumors, exploratory surgery with biopsy followed by adequate radiation therapy may result in definite palliation and long survival.

D. C. GASTINEAU, M.D.

Indiana University

Radiotherapy in Bladder Carcinoma. E. W. Frecker. *M. J. Australia* 1: 205-207, Feb. 12, 1955.

There are three methods of treating cancer of the urinary bladder: surgery, electrosurgery, and radiotherapy. This article discusses only the last. The conditions for its success are: (1) radiosensitivity of the tumor, (2) a uniform high dose, (3) dosage localized to the tumor, (4) fractionation. The author compares bladder tumors to skin lesions, which are ideal to treat since they are radiosensitive and available. Bladder tumors are usually radiosensitive (papillary more than infiltrating) but are deeply situated and therefore require special procedures.

The most usual method of irradiation of bladder tumors is radon seed implantation after the electrosurgical removal of cancer tissue. The dosage is carried as high as 7,500 r for small lesions. Calculations are made according to the data of Paterson and Parker. Lesions over 1.5 cm. in thickness require a double plane or volume implant and usually are better treated by external irradiation. If this is planned, it is well to place a seed in the center of the tumor for x-ray localization. Radium needles or radioactive isotope wires have also been used.

External irradiation with x-rays at voltages from 200 kv to millions of volts is useful for lesions not suitable for implantation. Best results are obtained with multiple small portals accurately located and accurate beam direction. A usual tumor dose is 6,000 r in five to six weeks. Complications are few, and the results are good. If cure is not possible, palliation may often be obtained with 2,500-3,000 r in two weeks.

Intracavitary methods are also described but are not considered satisfactory.

PAUL MASSIK, M.D.

Quincy, Mass.

Tumors of the Testis. Samuel L. Raines and Thomas G. Hurdle. *J. Urol.* 73: 363-372, February 1955.

This is an analysis of 50 cases of malignant testicular tumors, including 2 cases of bilateral involvement. The ages of the patients ranged from twenty to fifty-five, with an average of 32.6 years. Seminomas occurred in older men (average thirty-five years), and teratocarcinomas in the youngest patients (average twenty-eight years). The left testicle was involved in 52 per cent of the series; the right in 44 per cent. One patient had bilateral simultaneous embryonal-cell carcinomas, with a rapidly fatal course. The second case with bilateral (but not simultaneous) involvement occurred in a bilaterally cryptorchid pseudohermaphrodite. The types of tumor were as follows:

Seminoma.....	24 cases (48%)
Embryonal carcinoma.....	16 cases (32%)
Teratocarcinoma.....	9 cases (18%)
Unlisted.....	1 case (2%)

The Friedman test was positive in 6 cases, but no pure chorioepitheliomas were seen.

Associated findings were gynecomastia in 2 cases and hydrocele in 5. The differential diagnosis includes hydrocele, epididymitis, and orchitis. Metastases may occur early and be symptomless.

Treatment consists of simple orchiectomy with amputation of the cord at the internal inguinal ring, followed by supervoltage x-ray therapy. Treatment above the diaphragm is not given unless there are metastases. For seminomas, 2,000 r in two weeks was considered the ideal dose. Embryonal carcinomas and teratocarcinomas received 3,000 to 3,500 r in two to four weeks. In only 5 cases was radical retroperitoneal lymphatic dissection done, followed by irradiation. Two of this number were dead and a third was dying at the time of the report.

The patients in this series were treated from 1947 through 1953. Forty-seven of them were followed, of whom 32 (68 per cent) were alive at the time of the report. The highest survival rate was in the seminoma group, 86 per cent of 22 patients. For 15 embryonal carcinomas, the rate was 53 per cent, and for 9 teratocarcinomas 55 per cent.

Excretory urograms are done preoperatively in most cases for periaortic lymph-node metastases, which cause ureteral deviation or ureteral obstruction. Post-irradiation urograms will show the rate and degree of shrinkage of the masses and thus serve as a guide to radiosensitivity. All deaths from embryonal carcinoma and teratocarcinoma occurred within a year. Seminomas follow a less rapid course.

Two roentgenograms; 2 photographs; 5 tables.

PAUL MASSIK, M.D.

Quincy, Mass.

A Photographic Method for Measuring the Distribution of Dosage from Radium Needles and Plaques. E. Tochilin. *Am. J. Roentgenol.* 73: 265-271, February 1955.

The author describes a photographic method of measuring shapes and intensities of radiation fields surrounding various combinations of radium sources. He points out that such a method offers a great advantage in certain arrangements of irradiators in which mathematical calculations would be laborious and time-consuming. Isodose curves were determined around several commonly used radium plaque loadings by use of x-ray film and densitometer readings. Those determinations presented in the text show close agreement with the mathematical calculations and curves derived from Quimby's data.

The author points out that his photographic method of measuring the distribution of radiation dosage has certain limitations because of energy dependence of x-ray films, dependence of film darkening on the angle of radiation incidence, and the possible error incident to the use of a small densitometer aperture. Each of these three factors and its relative importance is discussed.

Generally, the results obtained from photographic densitometry measurements are sufficiently accurate to justify their use in determining radiation fields around radium applicators.

Seventeen figures.

J. A. BARBER, M.D.

Cheyenne, Wyo.

RADIOISOTOPES

Comparative Value of the Basal Metabolic Rate, Chemical Protein-Bound Iodine, and Radioactive Iodine Excretion or Uptake in the Diagnosis of Borderline Hyperthyroidism When Used Individually or in Combination. Leslie Zieve, Bengt Skanse, and Alvin L. Schultz. *J. Lab. & Clin. Med.* 45: 281-285, February 1955.

The three most widely discussed measures for distinguishing between borderline euthyroid and borderline hyperthyroid patients are determination of the basal metabolic rate, of the chemical protein-bound iodine, and of the radioactive iodine uptake or excretion in twenty-four hours. An evaluation of the comparative effectiveness of the three tests and of their combined use was the object of the study reported here. In essence, it offers a further demonstration of the superiority of I^{131} in the diagnosis of hyperthyroidism and its ability to distinguish borderline states. The effectiveness of the protein-bound iodine as compared to the radioiodine is approximately 0.9. The basal metabolic rate contributes very little further information. The protein-bound iodine and the radioiodine tests are mutually interdependent. Since they are dependent upon the same factors for their operation, the addition of the protein-bound iodine determinations to the uptake rate of the isotope enhances the effectiveness only about 10 per cent.

[Perhaps some of the superiority of the radioiodine as contrasted to the protein-bound iodine test is inherent in the fact that it is somewhat dependent upon anatomical structure and an anatomical state, rather than merely a chemical state.—S.F.T.]

Eight graphs; 2 tables.

SYDNEY F. THOMAS, M.D.
Palo Alto, Calif.

Estimation of Thyroid Volume. An Anatomic Study of the Correlation Between the Frontal Silhouette and the Volume of the Gland. Erkki Himanka and Lars-Gunnar Larsson. *Acta radiol.* 43: 125-131, February 1955.

Estimation of thyroid volume preparatory to thyroid irradiation with radioactive iodine can be obtained from clinical examination, roentgenograms, or "scanning" with a scintillation counter. The first two methods often lead to inaccurate estimates. An average error of only 10 per cent has been reported for estimations based on the frontal silhouette of the gland obtained by "scanning" (Allen and Goodwin: *Radiology* 58: 68, 1952). Two sources of error are involved: (1) an anatomic variation in the shape of the thyroid and (2) discrepancies between the frontal scintigram and the true anatomic silhouette. The present study is concerned with the first of these.

Postmortem examinations of 44 thyroids were performed. The dissected thyroid, larynx, and trachea (with the thyroid in its original position around the trachea) were placed on paper and the frontal outline of the gland was marked by pins placed sagittally. The thyroid was then removed and its volume determined by fluid displacement.

Comparison of actual volumes with the volumes estimated from these accurate frontal silhouettes revealed discrepancies considerably wider than those previously reported from scanning technics. It is thus apparent that thyroid volume estimations from frontal

scintigrams are inexact. Moreover, the complicated shape of the thyroid suggests that it will be difficult to devise a scintigraphic method which will work any more accurately than those in use at present.

It is better, however, to have a rough estimate of thyroid size than none at all. Also, in studying distribution of I^{131} in the thyroid, the scintigram will continue to be useful.

Knowledge of thyroid volume and uptake of I^{131} after a tracer dose are needed to calculate the required dosage for treatment. These determinations from frontal scintigrams probably are not sufficiently precise to permit critical analysis of treatment results.

One figure; 2 diagrams.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Simultaneous Measurement of the Iodide-Concentrating and Protein-Binding Capacities of the Normal and Hyperfunctioning Human Thyroid Gland. Sidney H. Ingbar. *J. Clin. Endocrinol. & Metab.* 15: 238-264, February 1955.

A procedure is described which makes possible in man the simultaneous measurement of the ability of the thyroid gland to concentrate inorganic iodide and to bind thyroidal iodide to protein. For the details of performance, the original article must be consulted. The method is based upon the following assumptions regarding the metabolism of iodine during the period of study: (1) The magnitude of the thyroidal iodide space remains constant. (2) Exchange of inorganic iodide between the thyroid and the plasma is very rapid. The specific radioactivity of iodide in the plasma is, at any moment, equal to that in the thyroid gland. (3) A constant percentage of thyroidal inorganic iodide is converted to hormonal iodine per unit time. (4) Release of newly formed radioactive hormone is negligible. (5) Radioiodide disappears from the plasma at an exponential rate.

The method has been applied to the study of thyroid function of 28 normal individuals and 20 patients with untreated Graves' disease. The data show that the increased rate of hormone synthesis found in the latter group was usually the result of increases in both the iodide-concentrating and protein-binding capacities of the thyroid gland. The importance of each of these factors in the production of abnormal thyroid function is stressed. The method also makes possible determination of a thyroid iodide transfer rate which measures the rate of transfer of plasma iodide to hormonal iodine and which can be applied to the study of patients receiving large doses of antithyroid drugs. The relation of this to other measures of thyroid function is discussed.

Five figures; 3 tables.

Radioactive Iodine Therapy in Euthyroid Cardiac Patient with Previous Mitral Commissurotomy. Frederick W. Pobirs and Henry L. Jaffe. *California Med.* 82: 121-124, February 1955.

A detailed and interesting case report is presented to illustrate the successful combined use of cardiac surgery (consisting of mitral commissurotomy and appendagectomy) and the medical induction of hypothyroidism by means of radioactive iodine. The patient, a Caucasian woman of 45 years with rheumatic heart disease,

first seen by the authors in 1945, exhibited progressive cardiac failure over the next several years with one certain and one possible episode of embolism. In 1952, mitral commissurotomy with appendectomy and evacuation of a large clot was carried out. The response was not entirely satisfactory, and it was decided to give the patient a course of radioactive iodine as a euthyroid cardiac. A total dose of 30 millicuries was given between July 17 and Aug. 31, 1952. Uptake determined on Oct. 21, 1952, was 2.58 per cent and on Dec. 9, 1952, was 1.19 per cent (hypothyroid range). At this time signs of edema began to appear and thyroid extract was given.

Three weeks after the completion of the course of radioactive iodine improvement began. The signs of failure which had been present for so many years disappeared. The patient became ambulatory and was able to resume simple household tasks. At the time of the last report she had had nineteen fairly comfortable months. The cardiac operation had removed the threat of further embolization and the hypothyroidism decreased the strain on the badly damaged heart.

F. F. RUZICKA, JR., M.D.
St. Vincent's Hospital, N. Y.

Further Experience with Intracavitary Radiocobalt for Bladder Tumors. Frank Hinman, Jr., John W. Schulte, and B. V. A. Low-Beer. *J. Urol.* **73**: 285-291, February 1955.

For the treatment of bladder tumors the author has for the past five years made use of intracavitary irradiation by radiocobalt beads. A bead is so placed in the central channel of a balloon catheter that when the bag is inflated the bead is held at the geometric center of the bladder. The intracavitary irradiation may or may not be combined with x-ray therapy.

The total radiation dose varies according to the treatment plan: 7,000 to 8,000 r tissue dose delivered in fifty to sixty days is considered essential for a cure. Three thousand to 4,500 r in forty days is given for arrest. When the disease has spread beyond the bladder or distant metastases are present, 300 to 1,500 r in one to three weeks is given for palliation. For eradication, the radiocobalt dose varies from 2,500 to 3,000 r, repeated in seven to ten days. Two types of cobalt beads were used: one of 20 millicuries equivalent inserted for one hundred hours; the other 80 to 90 millicuries for eight to ten hours. Reactions with the 20-millicurie beads were more severe. The x-ray dose is 3,500 r in thirty-five to forty days through four 10 X 10-cm. fields.

Thirty-five patients were treated up to 1953. Of this number, 25 were treated by radiocobalt alone. Ten had roentgen therapy in addition, but in 2 this was incomplete. Nine patients with lesions confined to the mucosa, or involving not more than half the thickness of the muscle, received a planned dose of radiation for eradication, and 4 of these were free of disease at the time of this report, the longest interval from treatment being four years. Twenty-two patients with more extensive disease were also treated with the intent of eradication, and 3 of these had been well for twelve to twenty-three months. Of 8 patients in whom the aim was arrest, 1 continued free of disease at fourteen months and another at twelve months.

The results indicate that surgery is preferable for superficial non-infiltrating lesions when these do not exceed three in number. Radiation is the treatment of

choice for multiple lesions. Tumors that extend more than 1 cm. in depth require external x-ray treatment in addition to intracavitary cobalt.

The sequelae of irradiation are often severe, consisting of radiation cystitis and bladder contraction.

Two tables.

PAUL MASSIK, M.D.
Quincy, Mass.

Use of Radioactive Cobalt (Co_{60}) in Nylon Sutures in Treatment of Carcinoma of Bladder: Preliminary Report. Vincent Vermooten. *J. Urol.* **73**: 280-284, February 1955.

The author describes the use of radioactive cobalt in nylon sutures in 2 cases: carcinoma of the bladder and carcinoma of the prostate. In the first case, the bladder wall was opened and the sutures were imbedded at 1-cm. intervals through and around the tumor. The bladder was then closed around a suprapubic tube. After six days the sutures were removed. Six weeks later the patient was almost asymptomatic. A recurrence at five months was treated in the same way, with good results.

An extensive recurrent carcinoma of the prostate was treated in a similar fashion. The sutures were implanted into the prostatic bed. The immediate result was good but the follow-up was brief.

Four roentgenograms; 3 photographs.

PAUL MASSIK, M.D.
Quincy, Mass.

Stray Radiation Measurements Around a Cobalt 60 Beam Therapy Installation. Lillian E. Jacobson and Isabelle S. Knauer. *Am. J. Roentgenol.* **73**: 272-280, February 1955.

The authors present a detailed monitoring study conducted on the cobalt 60 unit at the Montefiore Hospital, in New York. The unit was produced by Atomic Energy of Canada, Ltd. Isodose curves of stray radiation ("isostray curves") were plotted in all areas adjacent to the cobalt machine.

Details of the cobalt room design and the survey method are given, with the results obtained. It is concluded that a room designed for protection of any cobalt 60 therapy machine must be an individual problem. In general, however, the authors believe that 12-inch concrete walls and ceilings are adequate for scattered radiations, and that 3-foot concrete outside walls will afford protection from direct radiation. The isostray curves can serve as a guide for calculating thicknesses of wall and barrier protection at various distances from the cobalt unit.

Persons interested in the design of cobalt 60 therapy rooms are referred to the diagrams and charts presented in the text.

Twenty-five figures.

J. A. BARBER, M.D.
Cheyenne, Wyo.

The Use of Colloidal Au^{199} for the Detection of Lymph Nodes in Radical Excision of the Breast. K. A. Hultborn and L. I. Jonsson. *Acta radiol.* **43**: 132-138, February 1955.

Colloidal radiogold (Au^{199}) injected into the subareolar tissues of the breast is partially transported to and deposited within the regional lymph nodes. In 3 cases of breast carcinoma 1.0 to 3.0 mc of the isotope was injected into the breast and several days later radical mastectomy was performed. With the assistance of a directional scintillation counter the authors were able

to detect and remove lymph nodes in the axilla which ordinarily would have been overlooked.

No appreciable hazard to the surgeon's hands was apparent, and it is suggested that the procedure may prove useful in insuring more adequate axillary dissections during mastectomy.

Five illustrations. DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

A Study of the Lymph Drainage of the Lower Limb with the Use of Colloidal Radiogold (Au^{198}). K. A. Hultborn, L.-G. Larsson, and I. Ragnhult. *Acta radiol.* 43: 139-144, February 1955.

A method for study of the anatomy of lymph drainage of the lower extremity is presented. Tracer doses of colloidal radiogold (Au^{198}) were injected subcutaneously or intracutaneously over the calf or lateral aspect of the thigh in 5 patients. Deposition of the isotope in lymph nodes was then determined with the use of a directional scintillation counter. In each case uptake of radiogold was demonstrated in the external iliac lymph nodes. Uptake in popliteal nodes after calf injection and in the inguinal nodes after both calf and thigh injections was also observed.

Further studies may be expected to improve knowledge of regional lymph drainage from various body regions.

Eleven figures; 1 table.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Experiences with the Use of Radioactive Colloidal Gold in the Treatment of Cancer. H. Brownell Wheeler, William E. Jaques, and Thomas W. Botsford. *Ann. Surg.* 141: 208-217, February 1955.

This is a report of the authors' experience with radioactive gold (Au^{198}) in the treatment of cancer. Their cases have been almost equally divided between intracavitary and interstitial application. The theoretical advantages of colloidal gold over other internal sources of radiation, such as radium needles and radon seeds, are due to its physical properties, particularly its short half-life, its radiation spectrum, and the fact that it is used in a fluid medium. Careful dosage calculations were made in order to insure that each patient received approximately twice the number of roentgens usually considered an adequate dose in terms of conventional roentgen therapy. This dosage level was uniformly well tolerated and gradually the dose was increased in order to insure adequate irradiation of all areas of the tumor. No radiation sickness or sequelae referable to over-irradiation of surrounding normal tissues developed, and the reaction within the tumor itself was never such as to cause distress or danger. The only toxic manifestation observed was depression of the bone marrow in 4 patients who had received more than 50 mc of the isotope. Despite this associated marrow depression, the authors are not hesitant about giving large doses of the isotope if the situation so indicates.

The usual procedure for a small, isolated tumor nodule is to inject the mass thoroughly, administering as much fluid as the tumor will hold. In large tumors, not over 100 mc is distributed throughout the mass. The largest total dosage used has been 153 mc, in the peritoneal cavity. Now, however, the authors use about 100 mc for intraperitoneal injection, smaller dosages being considered ineffective and larger doses

being regarded as unnecessary and hazardous. For intrapleural injections the dose range is between 25 and 50 mc.

Forty-two patients received Au^{198} , some being given multiple treatments. With few exceptions, the cancer was disseminated and no prolongation of survival time was expected, nor did it occur. It was found that radiogold was of no benefit to the patient with a rapidly spreading lesion that was being widely disseminated by the blood stream. Lesions which tend to remain localized in one region, however, such as recurrent epidermoid carcinoma of the head and neck, can be treated with some hope of local palliation. Eight patients who received intrapleural injections in an effort to diminish formation of pleural effusions showed definite improvement. Only 3 of these required subsequent aspiration of fluid. No success attended peritoneal injection of radiogold in 9 of 42 patients treated; 36 were dead at the time of this report and 6 were alive, but the length of survival is not stated.

The histologic effects of radioactive gold injection are demonstrated by photomicrographs. The carcinolytic effect was usually sharply confined to the area injected. Tumors of the head and neck (epidermoid carcinoma) generally displayed marked carcinolysis; metastatic adenocarcinomas from the alimentary tract tended to show the least effect.

Two years clinical experience with this isotope have led to two main conclusions. One is that Au^{198} is a potent carcinolytic agent and the other is that its usage is sharply limited by the biological characteristics of the tumor.

The authors' present policy in the treatment of cancer with Au^{198} is as follows: (1) They believe it is the treatment of choice for those patients with peritoneal or pleural effusions caused by malignant disease. (2) The interstitial application of Au^{198} is reserved for malignant tumors that tend to spread by way of the lymphatics or are locally invasive. (3) This isotope should not be used in place of roentgen irradiation except where the latter has proved to be ineffective or cannot be applied for other reasons. (4) All patients who receive more than 50 mc of Au^{198} should have a complete blood count every week for three months because of the possibility of damage to the bone marrow.

Two photographs; 8 photomicrographs; 2 tables.

WYNTON H. CARROLL, M.D.
Shreveport, La.

The Use of Radioactive Gold Colloid in Inoperable Carcinoma of the Bladder. Charles M. Nelson and George Z. Williams. *J. Urol.* 73: 292-298, February 1955.

The authors report 2 cases of inoperable carcinoma of the bladder treated with radioactive gold colloid, with some relief of symptoms. Radioactive gold was considered to offer several advantages: it is a solution with a half-life of only 2.7 days, and 95 per cent of its emanations are beta rays which penetrate a distance of only 0.5 cm. The solution is readily injected into the tumor, giving a very high local radiation dose, with little distant effect.

In one of the cases 15 millicuries and in the other 20 millicuries of gold colloid was used. Both patients eventually succumbed to their disease.

Four photomicrographs; 1 photograph.

PAUL MASSIE, M.D.
Quincy, Mass.

A New Method of Treatment of Inoperable Brain Tumours by Stereotaxic Implantation of Radioactive Gold. A Preliminary Report. J. Talairach, G. Ruggiero, J. Aboulker, and M. David. *Brit. J. Radiol.* **28**: 62-74, February 1955.

Five cases of inoperable tumor of the brain treated by a new procedure based on a combination of fractional encephalography and the stereotaxic technic of Talairach (see *Presse méd.* **60**: 605, 1952) are reported. Good palliative results were obtained in 3.

After the lesion is localized by pneumographic and angiographic methods, radioactive gold is implanted through a small trephine by means of a needle guided through a template attached to the skull.

Thirty-three roentgenograms; 5 drawings.

SYDNEY J. HAWLEY, M.D.
Seattle, Wash.

Prophylaxis and Palliation of Malignant Effusions with Radioactive Colloidal Gold. Irving I. Cowan and Frank G. Kariotis. *Am. J. Obst. & Gynec.* **69**: 312-319, February 1955.

The authors report a series of 34 cases seen in 1952-53 in which radioactive gold was used prophylactically or therapeutically for accumulations of abdominal or pleural fluid associated with malignant tumors. The technic of administration and related radiation problems are discussed.

Ten patients were treated prophylactically following surgical exploration; in none of these did ascites develop, and 6 survived six months or longer. A total of 24 patients were treated therapeutically; 8 of these survived six months or longer, and in 7 palliation was obtained (repeated aspiration not required). When the desired effect was produced, the general condition of the patient improved.

Two tables.

R. L. EGAN, M.D.
M. D. Anderson Hospital, Houston

Colloidal Gold Infusion Unit. S. Allan Lough. *Nucleonics* **13**: 62-64, February 1955.

An easily portable colloidal gold infusion unit is described. This unit is a modification of previously described apparatus (Yalow and Cohen: *Nucleonics* **11**: 65, December 1953. *Abst. in Radiology* **63**: 623, 1954) and is particularly designed for use with bottles containing individual doses of radiogold. A shielding arrangement provides convenient portability of the apparatus. The arrangement of the tubes and dilution bottles permits repeated use without contamination. In operation, radiation exposures to personnel are limited.

One figure.

JOHN S. LAUGHLIN, Ph.D.
Memorial Center, New York

Radioactive Chromic Phosphate in Treatment of Urological Tumors. Vincent Moore, Dean Gamble, Raymond L. Libby, and Willard E. Goodwin. *J. Urol.* **73**: 410-416, February 1955.

Twenty-five cases of inoperable carcinoma of the prostate or bladder have been treated palliatively by manual interstitial injection of radioactive chromic phosphate in the Radiology Department of the University of California, Los Angeles. Radioactive phosphorus is a pure beta emitter, making it safe to handle and resulting in few side effects. One gram of prostatic tissue will hold 0.1 ml. of injected fluid without leakage. The given dose per gram was 100 microcuries of P^{32} .

All possible tumor tissue was resected transurethrally. Two weeks later the injection was made into the residual tumor, through a suprapubic bladder incision, care being taken to avoid spillage and to wall off all other surfaces. It appeared from subsequent transurethral biopsies that the injected isotope exerted a profound effect on the tumor tissue. In the amount used it was apparently without serious systemic or local toxic effects. Patients experienced prompt relief of bladder symptoms even in the presence of ultimately fatal extravascular tumor extension.

The importance of a uniform distribution of the isotope in the tumor is stressed. This problem is now being studied with an electrically powered automatic isotope injector which delivers a standard volume of isotope under uniform reproducible pressure.

Four photomicrographs; 2 tables.

PAUL MASSIK, M.D.
Quincy, Mass.

Hypophysectomy with Radioactive Chromic Phosphate in Treatment of Cancer. Sanford F. Rothenberg, Henry L. Jaffe, Tracy J. Putnam, and Benjamin Simkin. *Arch. Neurol. & Psychiat.* **73**: 193-199, February 1955.

The authors cite previous experimental and clinical evidence that destruction of the hypophysis is beneficial in certain forms of widespread neoplasms in man. After a few comments on the difficulty of surgical removal or destruction of the gland, they present a comparatively non-traumatic method of destroying it by radiation. This they call "hypophysectomy." Approximately 10 mc of chromic phosphate in a volume of 1.5 or 2.0 c.c. is injected into the substance of the hypophysis after proper surgical exposure. The irradiating material remains well localized in the pituitary fossa and delivers a very high dose of beta radiation to a small volume of adjacent tissue.

Six cases in which the procedure was used are reported: 3 of advanced carcinoma of the breast, 2 of widespread carcinoma of the thyroid, and 1 of carcinoma of the prostate. All of the patients represented apparently terminal stages of malignant disease and were requiring large doses of narcotics for pain. In each instance, certain postoperative, postirradiation endocrine replacements were required, particularly cortisone and sodium chloride. There is some evidence that thyroid substance and possibly androgens will become necessary as anti-anemic measures. One of the patients died shortly after operation, but the other 5 showed considerable reduction of pain. The follow-up periods were brief—six months to a year.

One radioautograph.

J. W. BARKER, M.D.
Cheyenne, Wyo.

Radiotracer Studies on Bone, Cementum, Dentin and Enamel of Rhesus Monkeys. Reidar F. Sognnaes, James H. Shaw, and Rita Bogoroch. *Am. J. Physiol.* **180**: 408-420, February 1955.

The relative distribution of radioactive phosphorus (P^{32}), iodine (I^{131}), potassium (K^{42}), sodium (Na^{24}), and water was determined in bone, cementum, dentin, and enamel of Rhesus monkeys, five minutes to five hours following radioisotope administration by various routes. Intravenously administered I^{131} was distributed in a relatively uniform manner throughout the mesenchymal hard tissues at a level 5 to 100 times higher than in the enamel of unerupted and erupted teeth, respectively.

These levels, which are believed to reflect relative permeability, did not change appreciably from five minutes to five hours.

In functioning bones and teeth, there was a decreasing uptake of P^{32} , given intravenously, in the following order: alveolar bone, calvarium, shaft of long bone, cementum, internal dentin, external enamel, external dentin, and internal enamel. In the mesenchymal hard tissues, bone, cementum, and dentin, the highest activity was concentrated in the surface layers adjacent to the cellular and vascular environment: periosteum, endosteum, pericranium, dura mater, periodontal membrane, dental papilla, and pulp. In unerupted teeth there was a remarkably high radiophosphorus uptake throughout the enamel, with a sharply increasing gradient from the incisal to the cervical portion. This gradient is thought to reflect greater penetration and exchange as well as submicroscopic growth of the inorganic crystals.

In the enamel of erupted teeth there was a markedly increasing radioisotope gradient toward the surface. This surface activity appeared to be contributed by contact with the salivary circulation. This suggests a liquid-solid relationship between saliva and enamel similar in kind, if not in magnitude, to that existing between extracellular connective-tissue fluid and the mesenchymal hard tissues. A two-way transport of ions through the teeth was observed. Intravenously administered I^{131} , P^{32} , K^{42} , Na^{24} , and H^3 were transported from the internal blood supply through dentin and enamel into the surrounding salivary environment; externally applied I^{131} was transported through enamel and dentin to become concentrated in detectable quantity in thyroid and urine.

The authors suggest that further comparisons of the radioisotope distribution in bone with that in the cementum, dentin, and enamel of the teeth may elucidate the relative significance of the several metabolic compartments controlling the physiology and pathology of the mineralized tissues.

Nine figures; 5 tables.

Surface Scintillation Measurements in Humans of the Uptake of Parenterally Administered Radioactive Vitamin B_{12} . George B. Jerzy Glass, Linn J. Boyd, and Gerald A. Gellin. *Blood* 10: 95-114, February 1955.

The authors have approached the problem of metabolism of vitamin B_{12} by isotopic technic, using vitamin B_{12} containing radioactive cobalt 60. In animals the radioactive vitamin B_{12} was used for quantitation of the excretion of vitamin B_{12} in the urine and feces, as well as for the study of its absorption and storage in various organs of the body. By means of surface measurements with a technic similar to that used for quantitation of I^{131} uptake, the uptakes of radioactive vitamin B_{12} by various body areas were determined.

The dose of radiation in roentgen equivalent physicals (rep) delivered to the liver (where the largest amount of $Co^{60}-B_{12}$ is stored) was calculated. Injected amounts were well below the permissible limit of $3\mu r$ of Co^{60} per individual, and dose to the liver was one-fourth of the allowable 0.3 rep per week.

Radioactivity counts were maximal over the liver, next highest over the spleen and kidney area, next over the iliac crest, and lowest over the calves and forearms. It was apparent that uptake by various organs differed under normal and pathological conditions.

The radioactive vitamin B_{12} disappeared rapidly from

the site of injection. Over 96 per cent was absorbed within three to four hours following injection. Within one to four hours, radioactivity uptake reached a peak over the left kidney and spleen. Over the liver the peak was attained between the third and seventh days, and 65 to 85 per cent of the peak activity was retained, in normal subjects, for two or three months thereafter. Grossly similar distribution curves were obtained following intramuscular and intravenous injections. It appeared that there was slightly faster elimination of vitamin B_{12} through the kidneys after intravenous injection. Other observations suggest that totally gastrectomized patients absorb vitamin B_{12} more rapidly from the injection site and discharge it more rapidly from the liver.

The storage of vitamin B_{12} in the liver for many months may explain the long time needed in man for depletion of hepatic stores of vitamin B_{12} , as well as the prolonged remissions observed in pernicious anemia following parenteral treatment with liver extracts or vitamin B_{12} .

Seven graphs; 4 tables.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Scintillation Counting for Multiple-Tracer Studies. G. J. Hine, B. A. Burrows, L. Apt, M. Pollycove, J. F. Ross, and L. A. Sarkes. *Nucleonics* 13: 23-25, February 1955.

Two different isotope tracers are often used simultaneously in advanced clinical investigations. If the half-lives of the isotopes are greatly different the fate of the labeled compounds can be distinguished by counting studies on a time basis. Even if the half-lives are relatively similar, the different isotopes can still be distinguished if their beta- or gamma-ray energies are significantly different.

The authors have developed and applied scintillation counter technics to the problem of differential counting of chromium 51 and iron 59 employed in clinical red blood cell studies. The dissimilar pulse energy spectra produced by the dissimilar gamma-ray spectra of these two isotopes are illustrated. The use of a pulse-height discriminator makes it possible to separate the counting rates due to each.

This technic is not effective in the case of potassium 42 and sodium 24, but these isotopes can be distinguished by virtue of their different beta- and gamma-ray spectra. A sodium iodide well-type scintillation counter is primarily sensitive to gamma rays and favors the detection of sodium 24. The energetic beta rays from potassium 42 will pass through an absorber thick enough to absorb the beta rays from sodium 24. A plastic-phosphor-well counter and a sodium iodide well-type scintillation crystal of similar dimensions distinguish between the sodium and potassium in a mixed sample. The interior well surface of the plastic phosphor is covered with a sufficient thickness of black scotch tape to absorb most of the sodium 24 beta rays. Tables and figures illustrate the details of this technic.

JOHN S. LAUGHLIN, Ph.D.
Memorial Center, New York

Clinical Research Using Compounds Labeled with Radioactive Carbon and Hydrogen as Tracers. George V. LeRoy. *Ann. Int. Med.* 42: 239-250, February 1955.

In a healthy organism a complex chemical system is

in equilibrium. The input of food and oxygen is nicely balanced by the output of work and waste products. In disease this system is out of balance. Isotopes are now being used to investigate these relationships. Four concepts of physiologic importance enter into such studies: (1) the volume of a system and its components; (2) the concentration of constituents; (3) turnover, or the rate at which input, output, and inter-conversion occurs; (4) the precursor-product relationship. The author elucidates these concepts by way of examples and references to the literature.

Turnover time for protein-bound radioiodine injected intravenously, for example, may be determined by obtaining the radioactivity of periodic blood samples and plotting this against time. *Turnover rate* is obtained by dividing the total amount of substance in the system by the turnover time. *Space and mass relations* are determined by application of the isotope dilution principle. The modern concept of *precursor-production relation* is almost wholly dependent upon isotope tracer studies, which permit the identification of the actual precursors of a chemical compound. Isotopes of hydrogen and carbon play the principal role here.

Cholesterol affords an example of the application of the precursor-product relationship. This two-carbon molecule is of increasing interest in studies of metabolism because of its great biochemical activity, and be-

cause it provides two-carbon units for many compounds. It is now established that, except for that of dietary origin, all the body's cholesterol is synthesized from acetate. Since acetate is believed to be the sole precursor of cholesterol, and since the plasma cholesterol is in equilibrium with cholesterol synthesized in the liver, it is possible to estimate the rate of cholesterol formation in man following the administration of C^{14} -labeled acetate.

Eight illustrations.

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The Biologic Decay Rates and Excretion of Radiocesium, Cs^{134} , with Evaluation as a Tracer of Potassium in Dogs. S. A. Threefoot, G. E. Burch, and C. T. Ray. *J. Lab. & Clin. Med.* 45: 313-322, February 1955.

Radiocesium was administered intravenously to three dogs. Its distribution in erythrocytes, whole blood, and plasma, and its urinary and total excretion were studied. Equilibrium of distribution was not established, and the excretory rate of Cs^{134} was found to be only about half that of potassium. It is concluded that Cs^{134} is not a satisfactory tracer for the estimation of space and mass of potassium in the dog.

Six figures; 3 tables.

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RADIATION EFFECTS

The Effects of Irradiation of the Pelvis in Patients with Carcinoma of the Cervix Uteri on the Iliac and Sternal Marrow and on the Peripheral Blood. Lucile W. Hutaff and Helen W. Belding. *Am. J. Roentgenol.* 73: 251-258, February 1955.

To determine the effect of local irradiation in therapeutic doses on adjacent and distant bone marrow, samples of bone marrow were obtained from 12 patients with carcinoma of the cervix, before treatment and at various stages during and after therapy with roentgen rays and radium. The local effect of irradiation was studied on iliac crest marrow while effects on distant marrow were determined by examination of samples from the sternum.

Irradiated marrow from the iliac crest showed a relative decrease in erythrogenic cells and an increase in mononuclear components beginning early after institution of radiotherapy. Somewhat later a repression of lymphocytic elements was demonstrated. Recovery of the irradiated marrow was reasonably rapid in all studied instances, and an essentially normal pattern was regained after about six weeks.

Samples of sternal marrow showed hypercellularity of all elements, with a pronounced rise in erythrogenic cells. Survey studies of peripheral blood showed the well known absolute leukopenia, neutropenia, and lymphopenia.

The authors conclude that apparently depression of bone marrow in the local (pelvic) zone of irradiation is compensated for by hypercellular changes in the distant (sternal) marrow. They believe that the compensatory effect of marrow distant from the site of irradiation accounts for the effective return of the peripheral blood picture to normal values.

Three photomicrographs; 1 graph; 3 tables.

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Tolerance Dose and Permissible Weekly Exposure to X and Gamma Radiation. Hannah Peters. *Indian J. Radiol.* 9: 40-43, February 1955.

Historical and experimental data leading to the adoption of presently accepted permissible or tolerance dose exposures to roentgen and gamma radiations are cited. It is stressed that the demonstrated effects of chronic radiation on one animal species cannot be assumed to apply to other species, including man. It does appear, however, that some responses to radiation exposures are related in different biological systems. The author feels that a justifiable comment arising from recorded data is that either the maximum permissible dose for man has been too high in the past, or that recorded blood changes are transitory and of no lasting significance. The only way to decide which assumption is correct is to evaluate accurately personnel monitoring records over a long observation period. In the meantime, it is suggested that the Swedish proposals for a roentgen ray "tolerance dose" of 100 milliroentgens per week, total-body irradiation, be accepted.

JAMES W. BARBER, M.D.
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Late Clinical Changes Following the Internal Deposition of Radioactive Materials. William B. Looney. *Ann. Int. Med.* 42: 378-387, February 1955.

In view of the increasing use of radioactive materials for medical, military, and industrial purposes, a knowledge of the late effects of internal deposits of such substances is important. The author has reviewed the literature particularly as it concerns observations on luminous dial painters, persons who received radium medically prior to 1940, and individuals who were given Thorotrast for diagnostic purposes ten to forty years ago. He refers also to his own observations.

Most of the radium taken into the body is eliminated.

That which is retained is deposited in the skeletal system, notably the fibula, femoral head, and radius. Bone destruction and production finally result, as well as "aseptic bone necrosis." The bones are sensitive to trauma and may fracture readily. Symptoms occur on an average of fifteen years after deposition. Sarcoma may eventually develop. In the dial painters studied by Martland marked pancytopenia occurred, but this has not been a feature of more recent cases. The author's own studies showed an elevated sedimentation rate (above 20 mm. in an hour), in 34 of 39 patients.

Thorium dioxide (Thorotrast) was first used in this country in 1930 in diagnostic radiology, but its use has decreased because of the formation of dense fibrotic reactions at the site of injection and because of the potential carcinogenic effects from the radioactivity. The primary sites of deposition are in the reticulo-endothelial system of the liver, spleen, and bone marrow, with lesser amounts in the lungs, adrenals, etc.

Comparatively little radiation reaction of the tissues to Thorotrast is noted. Roentgen study shows intensification of the liver and spleen shadow and may eventually reveal slight thickening of the bone shafts and their trabeculae. Minor hematologic changes have been reported, and some changes in liver function. There have developed a few neoplasms and leukemias, the relation of which to Thorotrast is not definitely established.

Three tables. WILLIAM SNOW, M.D.
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Response of the Burro to 100 r Fractional Whole Body Gamma Ray Irradiation. Thomas J. Haley, Eve F. McCulloh, W. G. McCormick, Bernard F. Trum, and John H. Rust. *Am. J. Physiol.* **180**: 403-407, February 1955.

A study has been made of the response of the burro to 100 r daily Co^{60} gamma-ray acute whole-body irradiation. The general symptoms of radiation injury were similar to but slower in developing than those after higher daily doses (see, for example, Cronkite: *Blood* **5**: 32, 1950; Rust *et al.*: *Radiology* **60**: 579, 1953; Trum *et al.*: *Am. J. Physiol.* **174**: 57, 1953. *Abst. in Radiology* **64**: 321, 1955). A pronounced lymphopenia occurred one hour after the first 100-r dose. The thrombocytes followed the pattern of response obtained when either 200 r fractional or a single LD 50 dose given. However, generalized bleeding from small wounds did not occur until the twenty-first day, whereas it occurred on the ninth day in the 200-r series. A significant hyperferremia was observed when the total irradiation reached 400 r, and two maximal responses were obtained, one after 800 r and the other after 1,500 r. Plasma iron was significantly elevated at exitus. A primary hypoferremia associated with a pronounced leukocytosis followed by a secondary hyperferremia was observed in one animal. The possible site of origin of this plasma iron is discussed.

Effects of Combined Whole Body Roentgen Irradiation and High Explosive Blast Injury in Mice. Carl Johan Clemenson and Arne Nelson. *Acta radiol.* **43**: 161-172, February 1955.

In view of the presumed association of blast and irradiation injuries in the event of future atomic warfare, the authors studied the effects of a combination of these two types of injury in mice. Four hundred and eighty white male mice were exposed to roentgen irradiation in doses ranging from 25 to 600 r. A few

hours thereafter the animals were exposed to a high explosive blast in a special detonation chamber.

The effects of this twofold injury on survival of the animals and their body weight was not found to differ significantly from what was to be expected after either type alone. Individual observations, however, reflected some depression in weight due to radiation injury with the higher exposures. An unexpected acceleration in weight gain was observed about two weeks following the highest blast pressures, and it is suggested that these pressures somehow improved resistance to pulmonary infections.

Ten figures; 1 table.

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Effect of X-Rays and Hormones on Resorption Rate of Injected $\text{NaHC}^{14}\text{O}_3$. Arne G. Forsberg and George Hevesy. *Am. J. Physiol.* **180**: 325-330, February 1955.

The authors found C^{14}O_2 exhalation following intraperitoneal injection of C^{14} -labeled sodium bicarbonate ($\text{NaHC}^{14}\text{O}_3$) to be markedly decreased after irradiation of mice with 2,000 r x-rays. This is due to a depressed resorption rate of the sodium bicarbonate. Because of the rapid exhalation of C^{14}O_2 , this effect appears during the first minutes after injection of the isotope and is reversed five to six minutes afterward to give an increased output of C^{14}O_2 .

Because of the possibility that the x-ray effects were mediated through hormonal action, the authors investigated the effects of subcutaneous injection of ACTH on the same process. ACTH increased the C^{14}O_2 exhalation *per se*, and its administration before irradiation annihilated the effect of the latter. It is not out of question, therefore, that the x-ray effect is due to a blocking of ACTH formation. Adrenalin decreased the output of C^{14}O_2 in the same manner as irradiation, but irradiation was not found to release adrenalin in the body. A combined treatment, with administration of adrenalin before irradiation, caused a higher output of C^{14}O_2 than from control mice. These facts are not compatible with the hypothesis that the x-ray effect is mediated through the action of adrenalin.

Two figures; 2 tables.

The Problem of Radioresistance in Biology and Medicine. G. Schubert. *Strahlentherapie* **96**: 271-273 February 1955. (In German)

The author tested the change in radiosensitivity of an Ehrlich carcinoma following repeated irradiation prior to transplantation. His observations, based on studies on more than 2,000 mice, showed that 1,100 r inhibited completely the growth of untreated transplants, but failed even to retard growth of pre-irradiated grafts.

Intracellular radioresistance is attributed to decreased inhibition of the mitotic cycle and is accompanied by increased capability of anaerobic glycolysis. An extracellular factor is increased partial pressure of O_2 , which improved growth retardation.

Increased radioresistance was still present after 25 animal passages. It is very likely not an adaptation phenomenon but brought about by mutation and the selective effect of radiation. The sensitivity factor is transferred from the primary tumor cell to all daughter cells, e.g., in lymph node metastases; it is thought to be gene-like in nature.

JURGEN L. SCHAPIRO, M.D.
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INDEX TO VOLUME 65

- ABBOTT, JOHN D.** See **BROWN, W. M. COURT**
- ABDOMEN**
- See also under names of abdominal organs and structures, as Aorta, Kidneys, Liver, Stomach, etc.
 - prophylaxis and palliation of malignant effusions with radioactive colloidal gold (ab), Irving I. Cowan and Frank G. Kariotis, Dec., 965
 - diseases**
 - renal anomalies: source of confusion in diagnosis of abdominal disease (ab), T. Burton Smith, Aug., 310
 - roentgenography.** See also **Pneumography**
 - diagnosis of hiatus hernia on plain roentgenograms of thorax and abdomen (ab), Francis J. O'Connor and Max Ritvo, Nov., 814
 - retroperitoneal insufflation. See **Pneumography**
 - value of a routine abdominal film (ab), Morris H. Levine and Stanley Crosbie, July, 145
 - surgery**
 - postoperative bronchopathies (ab), P. Mounier-Kuhn et al, Nov., 803
 - tumors**
 - collective review. Primary retroperitoneal tumors; 120 cases (ab), George T. Pack and Edward J. Tabah, Aug., 314
 - perforation of necrotizing primary retroperitoneal tumors into the gastrointestinal tract, Leo S. Figiel and Steven J. Figiel, Aug., 227
 - radiation therapy in retroperitoneal tumors (ab), Wm. E. Costlow and Wm. R. Wisdom, Dec., 960
 - retroperitoneal cavernous hemangioma associated with hemangiomas of skin in a newborn; case report and brief review of literature (ab), J. Richards Aurelius et al, Nov., 812
 - visualization of inferior vena cava as adjunct to diagnosis of retroperitoneal tumors; case (ab), John M. Keshishian and William A. Spencer, Oct., 630
- ABDULKERIM, ANIS, BOYD, JOSEPH A., and REEVES, ROBERT J.:** Treatment of hemangioma of the skin in infancy and childhood by roentgen irradiation and radium (a report of 323 cases) (ab), Sept., 482
- ABESHOUSE, BENJAMIN S., HELLER, EUGENE, and SALIK, JULIAN O.:** Vaso-epididymography and vaso-epididymography (ab), Sept., 481
- ABNORMALITIES.** See **Brain; Colon; Heart; Spinal Cord; Ureters**
- ABOULKER, J.** See **TALAIRACH, J.**
- ABRAMS, HERBERT L.:** Leiomyoma of the stomach (ab), Oct., 634
- Radiologic aspects of operable heart disease. I. Observations on the preoperative approach to congenital anomalies, July, 31
- ABSCISS**
- perigastric**
 - case report with preoperative roentgen diagnosis (ab), M. M. Mehta, Dec., 952
- ACETABULUM.** See **Hip**
- ACID**
- deoxyribonucleic acid.** See **Deoxyribonucleic Acid**
 - ethylenediamine tetra-acetic acid.** See **EDTA**
 - nucleic acid.** See **Nucleins**
- ACKERMAN, G. ADOLPH, BELLIS, NICHOLAS, C., KNOUFF, RALPH A., and FRAJOLA, WALTER J.:** Cytochemical changes in lymph nodes and spleen of rats after total body x-irradiation (ab), July, 156
- ACREE, PAGE W.** See **UCHSNER, ALTON**
- ACROMEGALY**
- (ab), J. M. Finlay and R. Ian Macdonald, Sept., 473
- ACROMION.** See **Shoulder**
- ACTINOMYCOSIS**
- actinomycotic diverticuloma of sigmoid colon (ab), Harry S. Hoffman, July, 133
- ADAMANTINOMA.** See **Tumors, adamantinoma**
- ADAMS, W. E.** See **LALLI, ANTHONY**
- ADENOMA.** See **Bronchi; Parathyroid; Tumors, adenoma**
- ADENOMATOSIS.** See **Lungs, cancer**
- ADENOMYOSIS.** See **Tumors, adenomyoma**
- ADENOSINE TRIPHOSPHATASE.** See **Phosphatase**
- ADHESIONS**
- See also **Intestines, ulcers**
 - extrinsic deformities of colon mimicking carcinoma; 3 cases (2 due to adherence of an epiploic appendix, 1 due to band of fibrous adhesions encircling right colon and ileum) (ab), Robert C. Overton et al, Sept., 471
- ADHIKARY, K. R.** See **MUKHERJEE, B.**
- ADLER, DENIS C., JACOBSON, GEORGE, HEITMANN, KENNETH A., and WATSON, DERRELL D.:** Insulin-induced hypermotility in the roentgen examination of the stomach and duodenum, Oct., 530
- ADLER, H.** See **POPPEL, MAXWELL H.**
- ADLERSBURG, DAVID.** See **MARSHAK, RICHARD H.**
- ADOLESCENCE**
- ossifying fibromas (fibrous dysplasia) of facial bones in children and adolescents (ab), Nicholas Georgiade et al, Nov., 796
 - roentgen examination of proximal femur end in children and adolescents: a standardized technic also suitable for determination of the collum-, anteversion-, and epiphyseal angles: a study of slipped epiphysis and coxa plana (ab), Lars Billing, July, 140
- ADRENALS**
- See also **Adrenocortical Preparations**
 - adrenal images obtained with retroperitoneal insufflation and operative control (ab), A. Lurà et al, Sept., 461
 - adrenal response to irradiation on patients with testicular tumors (ab), Ward O. Soanes and Claude C. Dodson, Aug., 315
 - hemostasis in sympathetomized and adrenalectomized animals before and after total-body x-irradiation (ab), Alfred L. Copley and Paul L. Stefkó, Oct., 651
 - lack of effect of adrenalectomy on tumor regression following x-irradiation (ab), Joanne W. Hollcroft and Marion Matthews, Aug., 322
 - pituitary and adrenal influences on insulin-¹³¹I degradation (ab), Neil J. Elgee and Robert H. Williams, Nov., 829
 - radiation sickness: a study of its relation to adrenal cortical function and the absolute eosinophil count (ab), Elliott C. Lasser and K. Wilhelm Stenstrom, July, 154
- tumors**
- pheochromocytoma; case (ab), S. J. Forrest and L. Goldberg, July, 145
- ADRENOCORTICAL PREPARATIONS**
- effect of Cortate and of Dramamine on selected group of patients undergoing deep roentgen therapy for carcinoma of cervix uteri (ab), E. C. Lasser and K. W. Stenstrom, Sept., 487
 - inhibition of acute x-ray damage by cortisone (ab), L. E. Houghton et al, Oct., 652
 - scleroderma: pulmonary and skin studies before and after treatment with cortisone (ab), A. Salomon et al, Dec., 957
- ADRENOCORTICOTROPIC HORMONE**
- effect of x-rays and hormones on resorption rate of injected NaHCO_3 (ab), Arne G. Forsberg and George Hevesy, Dec., 968
- ADVERTISING**
- teaching or advertising? (character of scientific exhibits) (ed), Robert P. Barden, Nov., 785
- AHLANDER, C.:** Combined treatment with roentgen rays and streptomycin in experimental tuberculous lymphadenitis in guinea-pigs (ab), July, 149
- AFRICA**
- management of keloid in South African Bantu (ab), J. C. Allan and P. Keen, Oct., 646
- AGE**
- collagenous changes in intervertebral disk with age and their effect on its elasticity: an x-ray crystallographic study (ab), A. Naylor et al, July, 139
- AITCHISON, I. D.** See **McKAY, J. M.**
- AJAMIL, LUIS F., and VALVERDE, MARIANO:** Cicatricial stenosis of vesical neck as a complication of retropubic prostatectomy (ab), Oct., 641
- ALARCON, DONATO G.:** Regressive giant bullous emphysema in tuberculosis of adults (ab), Nov., 801
- ALBERS, D.:** A study of the function of the cervical spine in dorsal and ventral flexion (ab), Sept., 476
- ALBERS, DONALD D.** See **KALMON, EDMOND H.**
- ALBRIGHT, FULLER.** See **JACKSON, W. P. U.**
- ALBUMIN.** See **Albuminuria, Blood, proteins**
- ALBUMINURIA**
- comparison of 5 gallbladder media (ab), E. E. Seedorf et al, Aug., 304
- ALDERMAN, ILO.** See **SMITH, WILLIE W.**
- ALEXANDER, J. A.** See **ALPEN, E. L.**
- ALIMENTARY TRACT.** See **Gastrointestinal Tract**
- ALLAN, J. C., and KEEN, P.:** Management of keloid in the South African Bantu (ab), Oct., 646
- ALLEN, FREDERICK M.:** Biological modification of effects of roentgen rays. I. Reduced temperature (ab), Nov., 833
- ALLEN, HERBERT C., Jr., and RISSER, J. R.:** Simplified apparatus for brain tumor surveys (ab), Nov., 827
- ALLEN, JOHN M.** See **BATT, HAROLD D.**
- ALLEN, R. PARKER:** Neuromuscular disorders of the urinary tract in children, Sept., 325
- ALLEN, WILLARD M., SHERMAN, ALFRED I., and ARNESEN, A. NORMAN:** Carcinoma of the cervix: results obtained from the irradiation of the parametrium with radioactive colloidal gold (ab), Oct., 647
- ALLINA, HANNAH.** See **GUSBERG, S. B.**
- ALMAND, JAMES R.** See **HUANG, KEE-CHANG**
- ALPEN, E. L., ALEXANDER, J. A., and DAVIS, A. K.:** Combined effects of total body x-irradiation and radiant energy thermal burns on the osmotic and mechanical fragility of the erythrocyte (ab), Oct., 651
- See **DAVIS, A. K.**

- ALPERT, MEYER, and LECHER, B. DOUGLAS:** Opacification of a calcified leiomyoma during hysterosalpingography (ab), July, 142
- ALTMAN, S. J.** See **WINTROBE, M. M.**
- ALUMINUM**
—x-ray attenuation in lead, aluminum, and concrete in the range 275 to 525 kilovolts, William Miller and R. J. Kennedy, Dec., 920
- ALVEOLAR-CELL CARCINOMA.** See Lungs, cancer
- AMERICAN BOARD OF RADIOLOGY,** Nov., 786
- AMINOPTERIN**
—cytochemical changes in lymph nodes and spleen of rats after total-body x-radiation (ab), G. Adolph Ackerman et al, July, 156
- AMYLOIDOSIS**
—of small intestine (ab), Ross Golden, July, 132
- ANDERSON, E. C.** See **VAN DILLA, M. A.**
- ANDERSON, ROBERT J., ENTERLINE, PHILIP E., and TURNER, OTIS D.:** Undetected tuberculosis in various economic groups (ab), Sept., 462
- ANDERSON, WILLIAM, JR.** See **SMITH, WILLIE W.**
- ANDREW, JOHN:** Sacralization: an aetiological factor in lumbar intervertebral disk lesions, and a cause of misleading focal signs (ab), Sept., 477
- ANDREWS, GOULD A.** See **ROOT, SAMUEL W.**
- ANDREWS, H. L.** See **BRACE, K. C.**
- ANEMIA**
—anemia and erythropoiesis in irradiated rat: an experimental study with particular reference to technics involving radioactive iron (ab), C. F. Baxter et al, Nov., 830
—combined effects of thermal burns and whole-body x-irradiation. II. Anemia (ab), A. K. Davis et al, Sept., 488
- ANESTHESIA**
—fires and explosions in anesthesia, John B. Dillon, July, 108
- ANEURYSM**
—some serious complications of tuberculous lymph nodes: fatal hemoptysis, false aneurysm, occluded cisterna chyli and obstructive jaundice: review, with report of 5 cases (ab), Godfrey L. Gale, Sept., 462
—venous aneurysms (ab), W. M. Hilscher, Dec., 951
- aortic**
—aortic sinus aneurysm associated with coarctation of aorta (ab), William Dubilier, Jr., et al, Nov., 805
—aortic sinus aneurysm; production of intracardiac calcification and pulmonary artery fistula (ab), Joseph C. Shipp et al, Nov., 805
—roentgenologic diagnosis of aneurysm of thoracic aorta, with particular reference to study in right posterior oblique position (ab), George Levene et al, Oct., 629
—traumatic aneurysms (ab), Edwin M. Goyette et al, Oct., 630
- cerebral**
—persistent carotid-basilar anastomosis associated with aneurysm of homolateral cerebral artery manifested by oculomotor palsy; case (ab), Frederick Murtagh et al, Nov., 765
—rupture of an intracranial aneurysm during cerebral angiography (ab), Kenneth G. Jamieson, Sept., 459
- hepatic**
—aneurysm of hepatic artery demonstrated roentgenographically; case (ab), Luther Jarvis and Philip J. Hodes, Oct., 632
- splenic**
—aneurysm of splenic artery (ab), Charles R. Downs et al, Dec., 951
- subclavian**
—thoracic outlet syndrome; case associated with short "first" rib, aneurysm of subclavian artery and occlusion of brachial artery (ab), J. R. E. Fraser and A. J. Barnett, Sept., 476
- ANGINA PECTORIS**
—treatment of incapacitated euthyroid cardiac patients with radioactive iodine: summary of results in 1,070 patients with angina pectoris or congestive failure (ab), Herrman L. Blumgart et al, Nov., 827
- ANGIOCARDIOGRAPHY.** See Cardiovascular System; Heart, abnormalities
- ANGIOGRAPHY.** See Brain; Extremities, blood supply
- ANGIOMA.** See Tumors, angioma
- ANGIORETICULOMA (hemangioblastoma).** See Tumors, angioma
- ANKLE**
—mechanism of total dislocation of talus (ab), Baldo Leitner, Nov., 819
—osteochondritis dissecans of talus, W. L. DeGinder, Oct., 590
—rigid valgus foot due to talocalcaneal bridge (ab), R. I. Harris, Nov., 819
- ANKYLOSIS.** See Elbow; Joints
- ANTIBIOTICS.** See Fallopian Tubes, tuberculosis
- ANTIBODIES**
—see also Immunity
—effect of repeated injections of Thorotrast on antibody production (ab), Lena A. Lewis, Oct., 652
—studies on transfer of lymph node cells. IV. Effects of x-irradiation of recipient rabbits on appearance of antibody after cell transfer (ab), T. N. Harris et al, Aug., 323
- ANUS**
—fistulous imperforate anus (ab), Peter Illery, Sept., 472
- AORTA**
—See also Aneurysm
—dysphagia and unusual radiographic appearances associated with variable relationships of aorta and lower esophagus (ab), Eric H. Mucklow and Oliver E. Smith, Aug., 296
—study of correlation between roentgenographic and post-mortem calcification of aorta (ab), Julian B. Hyman and Frederick H. Epstein, Aug., 296
—tracheographic and bronchographic studies as aids in diagnosis of congenital malformations of tracheobronchial tree and aortic arch in infants and children (ab), Charles F. Ferguson and Carlyle G. Flake, Oct., 628
—unilateral clubbing of fingers due to absence of aortic arch (ab), E. R. Dorney et al, Nov., 806
—value of selective angiocardiology in diagnosis of complete transposition of great vessels (ab), Åke Gyllenswärd and Herman Lodin, July, 127
- coarctation**
—aortic sinus aneurysm associated with coarctation (ab), William Dubilier, Jr., et al, Nov., 805
- roentgenography.** See also Kidneys
—abdominal aortography (ab), David M. Gould and James K. V. Willson, Sept., 466
—abdominal aortography for roentgen demonstration of liver and spleen (ab), Leo G. Rigler and Paul C. Offelt, Aug., 306
—aortography (ab), J. Sydney Ritter, Nov., 806
—aortography; further experiences (ab), Ian F. Potts, Dec., 956
—apparatus for automatic introduction of radiopaque media in translumbar aortography (ab), Martin Langsam and Nathan D. Wilensky, Aug., 312
—pneumia following translumbar aortography (ab), Saul Boyarsky, Aug., 298
—spinal cord damage in abdominal aortography (ab), Ragnar Hol and Odd Skjervén, Aug., 299
—translumbar arteriography in intrinsic disease of abdominal aorta and its branches (ab), Benjamin Felson, Aug., 296
- APPARATUS.** See Counters; Radioactivity; Roentgen Rays, apparatus
- APPEL, B.** See **SALOMON, A.**
- APT, L.** See **HINE, G. J.**
- ARAUJO, JORGE.** See **LUKAS, DANIEL S.**
- ARAUJO, JOSÉ.** See **MENESES HOYOS, JORGE**
- ARCOMANO, JOSEPH P.** See **BELL, A. L. L.**
- ARMS**
—See also Extremities
—lymphangiosarcoma in postmastectomy lymphedema; 5-year survival with irradiation treatment (ab), Harry W. Southwick and Danel P. Slaughter, Nov., 823
—phlebographic study of swollen arm following radical mastectomy (ab), S. Schorr et al, Aug., 300
- ARNESON, A. N.:** Cancer of the cervix (ab), July, 146
—See **ALLEN, WILLARD M.**
- ARNOIS, DOLORES C.** See **LEVENE, GEORGE**
- ARONS, WALTER L., CHRISTENSEN, W. R., and SOSMAN, M. C.:** Nephrocalcinosis visible by x-ray associated with chronic glomerulonephritis (ab), Dec., 957
- ARTERIES**
—See also Aneurysm; Aorta; Brain; Cardiovascular System; Extremities; Kidneys, blood supply; etc.
—arterial vascularization of soft tissues of hand (ab), Herbert Conway and Richard B. Stark, Oct., 632
—importance of radiology in geriatrics (arterial diseases) (ab), Juan José Quezada, Aug., 299
- basilar.** See Arteries, vertebral
- brachial**
—thoracic outlet syndrome; case associated with short "first" rib, aneurysm of subclavian artery and occlusion of brachial artery (ab), J. R. E. Fraser and A. J. Barnett, Sept., 476
- carotid**
—acute occlusion of internal carotid artery; 5 cases (ab), William R. Chambers, Sept., 459
—carotid-basilar anastomosis, with multiple associated cerebrovascular anomalies; case (ab), J. P. Schaefer, Nov., 795
—collateral circulation of external carotid artery and internal carotid artery through ophthalmic artery in cases of internal carotid artery thrombosis; 5 cases, Paul M. Lin and Michael Scott, Nov., 755
—persistent carotid-basilar anastomosis associated with aneurysm of homolateral middle cerebral artery manifested by oculomotor palsy; case (ab), Frederick Murtagh et al, Nov., 795
- coronary.** See Coronary Vessels
- glomerular.** See Kidneys, blood supply
- hepatic.** See Aneurysm, hepatic
- innominate**
—congenital subclavian arteriovenous fistula and a truncus brachiocephalicus totalis in same patient (ab), O. Peräsalo and K. E. J. Kyllönen, Aug., 297
- occlusion.** See Arteries, brachial; Arteries, carotid
- ophthalmic**
—collateral circulation of external carotid artery and internal carotid artery through ophthalmic artery in cases of internal carotid artery thrombosis; 5 cases, Paul M. Lin and Michael Scott, Nov., 755
- ovarian**
—ovarian artery: arteriographic study in human subjects (ab), Ulf Borell and Ingmar Fernström, Aug., 309

- ARTERIES—cont.**
pulmonary. See also Fistula, arteriovenous; Lungs, blood supply
 —aortic sinus aneurysm; production of intracardiac calcification and pulmonary artery fistula (ab), Joseph C. Shipp et al, Nov., 805
 —congenital absence of main branch (ab), J. E. Flynn et al, Oct., 630
 —pulmonary coarctation (ab), M. L. Powell and H. G. Hiller, Dec., 951
renal. See Kidneys, blood supply
roentgenography. See Aorta; Arteriosclerosis; other sub-heads under Arteries
splenic. See Aneurysm, splenic; Spleen
subclavian. See also Aneurysm; Fistula, arteriovenous
 —aberrant right subclavian artery (ab), E. A. Petrie, Oct., 631
vertebral
 —carotid-basilar anastomosis, with multiple associated cerebrovascular anomalies; case (ab), J. P. Schaefer, Nov., 795
 —myelographic demonstration of basilar artery (ab), Flora M. Brown and Ralph C. Aye, Nov., 795
 —percutaneous vertebral angiography (ab), Pierre Namin, July, 125
 —persistent carotid-basilar anastomosis associated with aneurysm of homolateral middle cerebral artery manifested by oculomotor palsy; case (ab), Frederick Murtagh et al, Nov., 795
 —some complications of vertebral angiography (ab), Oscar Sugar and Paul C. Bucy, Sept., 459
ARTERIOGRAPHY. See Arteries; Arteriosclerosis; Kidneys; etc.
ARTERIOSCLEROSIS
 —"in vivo" dissolution of metastatic calcium: an approach to atherosclerosis (use of EDTA) (ab), Norman E. Clarke et al, Dec., 957
 —peripheral arteriosclerosis: clinical and arteriographic evaluation with reference to conservative surgical treatment (ab), H. P. Totten, Aug., 299
 —serial arteriography in atherosclerosis (ab), G. C. Willis et al, Oct., 632
ARTHRITIS
 See also Hip; Spine
 —atrophy of auricular and nasal cartilages following administration of chorionic gonadotrophins in case of arthritis mutilans with sicca syndrome (ab), Fred B. Rogers and John Lansbury, Nov., 797
 —radiotherapy of arthrosis, spondylitis, periarthritis humeroscapularis and epicondylitis (ab), P. Hess and K.-H. Bonmann, Nov., 825
ARTHROGRAPHY. See Knee
ARTHROGYPOSIIS MULTIPLEX CONGENITA. See Joints, ankylosis
ARTHURTON, M. W., GIBSON, R. V., and WOODWARK, G. M.: Anomalous pulmonary vein drainage into the coronary sinus (ab), Aug., 298
ASCARIASIS
 —of biliary tract: radiologic demonstration by barium reflux (ab), S. Gasparini and C. Meneghini, July, 134
ASHWELL, GILBERT. See SMITH, WILLIE W.
ASTATINE. See Radioactivity
ATELECTASIS. See Lungs, collapse
ATHEROSCLEROSIS. See Arteriosclerosis
ATHLETICS
 —the radiologist and athletic injuries (ab), Everett F. Crutchlow, Oct., 638
ATLANTOAXIAL JOINT. See Atlas and Axis
ATLAS AND AXIS
 —headache as first and only sign of basilar impression (ab), William R. Chambers, Nov., 796
 —spontaneous subluxation of atlantoaxial joint with inflammatory processes in neck (ab), E. Kotscher, Nov., 797
 —x-ray demonstrable lesions in occipital headache; 9 cases (7 of platybasia) (ab), William R. Chambers, Aug., 291
ATOMIC BOMB
 —effects of combined whole-body roentgen irradiation and high explosive blast injury in mice (ab), Carl Johan Clemmelson and Arne Nelson, Dec., 968
 —pathology of swine exposed to total-body gamma radiation from atomic bomb source (ab), John L. Tullis et al, Nov., 833
 —radiation protection in atomic energy industry: a 10-year review, H. M. Parker, Dec., 903
ATROPINE
 —unsolved problems in x-ray diagnosis of peptic ulcer: the atropine test (ab), E. Ötvös, Oct., 634
AURAND, K. See RAJEWSKY, B.
AURELIUS, J., RICHARDS, PETERSON, DONALD H., and MIKNEJAD, ISMAIL: Retroperitoneal cavernous hemangioma associated with hemangiomas of the skin in a newborn. Case report and brief review of the literature (ab), Nov., 812
AUSTRALIA
 —mass x-ray survey; city of Sydney (ab), Charles Rubinstein, Nov., 799
AUTOPSIES
 —suggested procedure for performance of autopsies on radioactive cadavers (ab), Russell F. Cowing and Egilda DeAmicis, Aug., 319
AUTORADIOGRAPHY. See Radioactivity
AXILLA. See Lymph Nodes
AXILROD, HERBERT D.: Triplette ureter (ab), Sept., 481
AYE, RALPH C. See BROWN, FLORA M.
AZAD, MONOUCHEHR. See SPRAFKA, JOSEPH L.
B
BACHMAN, C. H., DAVIS, H. W., and GELORMINI, O. J.: Convergent beam roentgen tube (ab), Nov., 826
BACLESSE, F.: A method of pre-operative roentgentherapy by high doses, followed by radical operation for carcinoma of the breast (showing survivals up to 10 years) (ab), Nov., 823
BAIRD, I. McLEAN, GRAINGER, R., and ROWLANDS, B. C.: Hyperparathyroidism due to parathyroid adenoma. Report of six cases and review (ab), July, 138
BAKER, CHARLES R. See SOBIN, SIDNEY S.
BAKER, HARVEY W. See JOHNSON, ROBERT B.
BALLARD, S. C.: X-radiation from electronic power tubes (ab), Aug., 324
BALMES, A., and THÉVENET, A.: Pneumomediastinum in bronchial cancer (ab), July, 127
BANKER, ROBERT J., and CARD, WILLIAM H.: Calyceal diverticula (ab), Sept., 481
BANTHINE
 —gastrointestinal motility in man: influence of standard meal on effect of Bantline (ab), William P. Chapman et al, Oct., 634
BARIUM
 See also Intestines, roentgenography; Intussusception
 —ascariasis of biliary tract: radiologic demonstration by barium reflux (ab), S. Gasparini and C. Meneghini, July, 134
 —barium in hydrogen peroxide in esophageal and gastric diagnosis, Cesare Gianturco and George A. Miller, Oct., 569
BARLOW, JOHN. See SAMUEL, ERIC
BARNETT, A. J. See FRASER, J. R. E.
BARNETT, E., and BEWLEY, D. K.: Ovarian radiation during hysterosalpingography (ab), Nov., 819
BARONOFFSKY, IVAN D. See SPRAFKA, JOSEPH L.
BARRITT, D. W.: Simple pulmonary stenosis (ab), Aug., 298
BARSKY, PERCY: The x-ray delineation of ingested enteric-coated substances (ab), Dec., 952
BASILAR IMPRESSION. See Atlas and Axis
BASS, HYMAN E. See KATZEV, HERBERT
BATHS
 —study of effect of high temperature by hot baths, short waves and ultrasonics on cancer tissue and biological principles of combined x-ray-ultrasonics therapy of superficial tumors (ab), Karlheinz Woeber, Sept., 488
BATLAN, LAWRENCE E.: Calcification within the stomach wall in gastric malignancy. Case report and review of literature (ab), Sept., 469
BATT, HAROLD D., ALLEN, JOHN M., TREDER, FREDERICK H., and SHAPIRO, ROBERT: Photofluorographic detection of cardiovascular disease in a general hospital (ab), Oct., 629
BATT, RICHARD C.: Intravenous cholecystangiography, Dec., 926
BAUER, ROBERT E., MOSS, IRWIN H., and RICHARDSON, AUBREY D.: A study of radioactive phosphorus activities in pleural effusions (ab), July, 131
BAXTER, C. F., BELCHER, E. H., HARRISS, EILEEN B., and LAMERTON, L. F.: Anemia and erythropoiesis in the irradiated rat: an experimental study with particular reference to techniques involving radioactive iron (ab), Nov., 830
BAY, ROBERT C. See DOUGHERTY, JEAN H.
BEALE, HENRY D. See HARRIS, T. N.
BEAN, BERTEN C. See CULVER, GORDON J.
BECK, HANS E.: Contribution to the roentgenology of hiatus hernia and hiatus insufficiency (ab), July, 136
BECKER, IRVIN M.: Cystic dilatation of Brunner's glands (ab), Aug., 302
BEETHAM, W. R. See STOLL, BASIL A.
BEIRNE, MICHAEL F.: Malignant melanoma of the small intestine, Nov., 749
BELCHER, E. H. See BAXTER, C. F.
BELDING, HELEN W. See HUTAFF, LUCILE W.
BELL, A. L. L., IMMERMAN, LEWIS L., ARCOMANO, JOSEPH P., ZWANGER, JEROME, and BELLO, EDWARD T.: Intravenous cholangiography. A preliminary study (ab), July, 135
BELLADONNA
 —adverse effects of belladonna alkaloids in benign pyloric obstruction; experimental study (ab), Philip Kramer, July, 130
BELLIOS, NICHOLAS C. See ACKERMAN, G. ADOLPH
BELLO, EDWARD T. See BELL, A. L. L.
BENDICK, ARTHUR J.: A simplified, inexpensive technique in hysterosalpingography (ab), Sept., 479
BENIGNO, BENEDICT B.: Uterus duplex unicollis (ab), July, 142
BENNER, S., DAHL, O., HULTBERG, S., THORAEUS, R., and VIKTERLÖF, K. J.: Equipment and technique in precision rotation roentgen therapy (ab), Nov., 825
BENUA, RICHARD S., and DOBYNS, BROWN M.: Iodinated compounds in the serum, disappearance of radioactive iodine from the thyroid, and clinical response in patients treated with radioactive iodine (ab), Nov., 827
 —See MUELLER, RICHARD

- BERANBAUM, SAMUEL L., GOTTLIEB, CHARLES, and LEFFERTS, DAVID:** Gastric volvulus. Part III. Secondary gastric volvulus (ab), Aug., 301
- See **GOTTLIEB, CHARLES**
- See **LEFFERTS, DAVID**
- See **TWISS, J. RUSSELL**
- BERENS, DAVID L.** See **CULVER, GORDON J.**
- BERG, HAROLD F., CHRISTOPHERSEN, WILLIAM M., and BRYANT, J. RAY:** Time and site study for optimum lymph node concentration of radiogold following intrabronchial injection (ab), Oct., 647
- ISAACS, AVROM M., and CHRISTOPHERSEN, WILLIAM M.:** Localization of radioactivity in the urinary bladder and the regional lymph nodes (ab), July, 152
- BERGMAN, F., GORTON, G., NORMAN, O., and SJOSTEDTS:** Foreign body granulomas following hysterosalpingography with a contrast medium containing carboxymethyl cellulose (ab), Nov., 821
- BERMAN, HARRY L.:** Radical surgery after intensive irradiation (ab), Sept., 483
- BERNSTEIN, CHARLES.** See **HEILBRUN, NORMAN**
- BETA RAYS.** See **RADIOACTIVITY, radiophosphorus**
- BETATRON**
- See also **Electrons and Electronics**
- is rotation therapy with betatron of 15 to 31 mev energy advantageous? (ab), H. R. Schinz and R. Wideröe, July, 150
- pathogenesis of bone marrow injury in rats subjected to total irradiation with fast electrons (15-mev Siemens betatron) (ab), R. Stodtmeister and M. Th. Fliedner, July, 156
- BEWLEY, D. K.** See **BARNETT, E.**
- BIANCHI, GIACOMO:** Examination of the superior portion of the stomach by insufflation and stereoscopy (ab), Nov., 809
- BIAVATI, C.** See **LURÀ, A.**
- BICKEL, WILLIAM H.** See **HOLMAN, COLIN B.**
- BIERLING, G., and REISCH, D.:** Sudek's syndrome after fractures (ab), Nov., 815
- BIERMAN, HOWARD R.** See **KRISS, JOSEPH P.**
- BILE**
- limy ductus choledochus, Oscar H. Cohen, July, 78
- BILE DUCTS**
- See also **Biliary Tract**
- limy ductus choledochus, Oscar H. Cohen, July, 78
- BILIARY TRACT**
- See also **Bile Ducts; Gallbladder; etc.**
- ascariasis: radiologic demonstration by barium reflux (ab), S. Gasparini and C. Meneghini, July, 134
- roentgenography**
- estimation of liver function by cholangiography (ab), Eric Samuel et al., Nov., 811
- extension of immediate cholangiography in common duct surgery (ab), John A. Gius et al., July, 135
- intravenous cholangiography (ab), Frank Glenn et al., Aug., 305
- intravenous cholangiography: preliminary study (ab), A. L. L. Bell et al., July, 135
- intravenous cholecystangiography, Richard C. Batt, Dec., 926
- intravenous cholecystography and cholangiography: clinical trials with a new medium (Biligradin) (ab), David Sutton and John V. Tillett, Aug., 306
- 117 cases examined by intravenous cholecystocholangiography (ab), A. Maléki, Sept., 472
- operative cholangiography (ab), E. S. R. Hughes and R. H. Kernutt, July, 134
- operative cholangiography as aid in surgery for jaundice (ab), Stanley O. Hoerr, July, 135
- operative cholangiography: survey of present day opinions (ab), Carl W. Clark, Jr., Aug., 306
- postcholecystectomy oral cholangiography (ab), J. Russell Twiss et al., Nov., 812
- transduodenal cholangiography (ab), H. Gaylis and Kenneth Gunn, Dec., 953
- use of Cholografin in postcholecystectomy syndrome (ab), Edwin M. Cohn et al., Nov., 812
- visualization by means of Biligradin, especially after cholecystectomy (ab), Werner Teschendorf, Aug., 305
- BILIGRADIN.** See **Biliary Tract**
- BILLING, LARS:** Roentgen examination of the proximal femur end in children and adolescents. A standardized technique also suitable for determination of the collum, epiphysis, and epiphyseal angles. A study of slipped epiphysis and coxa plana (ab), July, 140
- BIOLOGY**
- Biological Photographic Association, July, 115
- problem of radioresistance in biology and medicine (ab), G. Schubert, Dec., 968
- BIOPHYSICS**
- graduate program in biophysics, Dec., 939
- BIRSNER, J. W.:** Roentgen aspects of five hundred cases of pulmonary coccidioidomycosis (ab), Aug., 292
- BISCHOFF, ARTHUR J.** See **THOMAS, GILBERT J.**
- BISCHOFF, MARTIN E., and STAMPFELI, WENDELL P.:** Meckel's diverticulum, with emphasis on the roentgen diagnosis, Oct., 572
- BLACKSTONE, ARCHIE W.** See **STAUFFER, HERBERT M.**
- BLADDER**
- cicatricial stenosis of vesical neck as a complication of retrophic prostatectomy (ab), Luis F. Ajamil and Mariano Valverde, Oct., 641
- late results of bladder substitution with isolated ileal segments (ab), Eugene M. Bricker et al., Aug., 312
- calculi**
- opaque vaginal suppository mistaken for bladder calculus (letter to editor), George E. Irwin, Jr., Nov., 788
- urinary tract calculi in children: renal and vesical calculi in 8-month-old child (ab), C. A. Moore and C. C. Dodson, Oct., 640
- cancer**
- intracavitary radiocobalt for tumors; further experience (ab), Frank Hinman, Jr., et al., Dec., 963
- localization of radioactivity in urinary bladder and regional lymph nodes (ab), Harold F. Berg et al., July, 152
- radioactive chromic phosphate in treatment of urological tumors (ab), Vincent Moore et al., Dec., 965
- radiotherapy in carcinoma (ab), E. W. Frecker, Dec., 961
- skeletal involvement in carcinoma of urinary bladder (ab), Denis E. Fletcher, Aug., 308
- treatment of carcinoma with artificial radioactivity: use of liquid radioisotope in balloon catheter with special consideration of a Co^{60} solution (ab), J. H. Müller, July, 151
- treatment of malignant tumors by irradiation (ab), D. S. Poole-Wilson, Oct., 644
- use of radioactive cobalt (Co^{60}) in nylon sutures in treatment of carcinoma; preliminary report (ab), Vincent Vermooten, Dec., 963
- use of radioactive gold colloid in inoperable carcinoma (ab), Charles M. Nelson and George Z. Williams, Dec., 964
- fistula.** See **Fistula**
- paralysis.**
- neuromuscular disorders of the urinary tract in children, R. Parker Allen, Sept., 325
- roentgenography**
- normal micturition: certain details as shown by serial cystograms (ab), Frank Hinman, Jr., et al., Nov., 821
- tumors**
- treatment of papilloma with radioactive colloidal gold, Au^{198} (ab), Frank Ellis and R. Oliver, Nov., 830
- BLAKE, HU A.** See **GOYETTE, EDWIN M.**
- BLANK, F.** See **MANKIEWICZ, EDITH**
- BLANK, LEO.** See **SPELLMAN, MITCHELL W.**
- BLASTING CAPS**
- metallic fragments of blasting caps as ocular foreign bodies (letter to editor), Donnan B. Harding, July, 115
- BLAZEK, O.** See **SOYKA, O.**
- BLOCKER, T. G., Jr., LEVIN, WILLIAM C., LEWIS S. R., and SNYDER, C. C.:** The use of radioactive sulphur labeled methionine in the study of protein catabolism in burn patients (ab), Aug., 319
- BLOMFELD, GEORGE W.:** Irradiation therapy in urology (ab), Oct., 644
- BLOOD**
- See also **Erythrocytes; Hemopoietic System; Leukocytes; etc.**
- comparison of effects of radiation and radiomimetic chemicals on blood (ab), L. A. Elson, Nov., 832
- effects of irradiation of the pelvis in patients with carcinoma of cervix uteri on iliac and sternal marrow and on peripheral blood (ab), Lucile W. Hutaff and Helen W. Belding, Dec., 967
- albumin.** See **Blood, proteins**
- chemistry**
- effect of total body x-irradiation on serum electrolyte levels and electrocardiograms of golden hamster (ab), George P. Fulton and Frederick N. Sudak, Aug., 322
- count.** See also **Leukocytes**
- effect of single dose of x-rays on peripheral blood count of man (ab), W. M. Court Brown and John D. Abbott, Nov., 832
- iodine**
- comparative value of basal metabolic rate, chemical protein-bound iodine, and radioactive iodine excretion or uptake in diagnosis of borderline hyperthyroidism when used individually or in combination (ab), Leslie Zieve et al., Dec., 962
- iodinated compounds in serum, disappearance of radioactive iodine from thyroid, and clinical response in patients treated with radioactive iodine (ab), Richard S. Benza and Brown M. Dolhys, Nov., 827
- simplified sensitive test for thyroid function, using protein-bound I^{131} (ab), L. Van Middlesworth et al., July, 151
- simultaneous measurement of the iodide concentrating and protein binding capacities of normal and hyperfunctioning human thyroid gland (ab), Sidney H. Ingbar, Dec., 962
- iron**
- effect of hydroxylamine and x-irradiation on red cell destruction and formation and serum iron concentration (ab), Alfred Chanutin and Elizabeth L. Word, Oct., 652
- proteins**
- clinical use of plasma butanol-extractable (thyroxin) I^{131} in diagnosis of hyperthyroidism and myxedema (ab), Alvin L. Schultz et al., July, 151
- comparative value of the basal metabolic rate, chemical protein-bound iodine, and radioactive iodine excretion or uptake in diagnosis of borderline hyperthyroidism when used individually or in combination (ab), Leslie Zieve et al., Dec., 962
- radioactive iodide uptake of normal newborn infants (ab), L. Van Middlesworth, Aug., 316

BLOOD, proteins—cont.

- significance of serum protein shifts in diagnosis of bone tumors (ab), Béla Gimes and Zoltán Szendrői, Sept., 475
- simplified sensitive test for thyroid function, using protein-bound ¹³¹I (ab), L. Van Middlesworth et al., July, 151
- simultaneous measurement of iodide-concentrating and protein-binding capacities of normal and hyperfunctioning human thyroid gland (ab), Sidney H. Ingbar, Dec., 962
- treatment of multiple myeloma with radioactive iodine and radioactive iodinated serum albumin, Joseph P. Kriss, Howard R. Bierman, Sydney F. Thomas and Robert R. Newell, Aug., 241
- volume**
 - pulmonary arterial oligemia in mitral stenosis as revealed on plain roentgenogram, Felix G. Fleischner and Elliot L. Sagall, Dec., 857
 - research on utilization of radioactive PO₄Cr in colloidal solution for determination of circulating blood volume (ab), O. Jalut et al., July, 153

BLOOD PRESSURE

- high**
 - angiographic study of renal circulation in experimental hypertension in dog (ab), P. M. Daniel et al., July, 143
 - hypertension in infancy, with anomalous renal artery; diagnosis by renal arteriography, apparent cure after nephrectomy (ab), C. Harrison Snyder et al., Nov., 808
 - obstruction of renal artery producing malignant hypertension (ab), Irving Imber and Robert H. Clymer, Jr., Dec., 957

BLOOD VESSELS. See Aorta; Arteries; Brain; Cardiovascular System; Hand; etc.

BLOOR, ROBERT J., and QUICK, RAYMOND S.: Treatment planning in roentgen therapy (ab), Oct., 642

BLOUNT, HENRY C., Jr.: Effect of magnesium on the response of mice to large doses of whole-body irradiation, Aug., 250

BLUMBERG, NATHAN. See GERSHON-COHEN, JACOB

BLUMENFELD, MARGARET. See ELDRIDGE, FREDERIC L.

BLUMENFELD, SERGE. See VOGL, ALFRED

BLUMGART, HERRMAN L., FREEDBERG, A. STONE, and KURLAND, GEORGE S.: Treatment of incapacitated euthyroid cardiac patients with radioactive iodine. Summary of results in treatment of 1,070 patients with angina pectoris or congestive failure (ab), Nov., 827

BÓDI, TIBOR, FANGER, HERBERT, and FORSYTHE, THOMAS: Spontaneous rupture of the esophagus (ab), July, 129

BODY-SECTION ROENTGENOGRAPHY

- laminae in acute maxillofacial injuries, Richard F. McClure, Sept., 408
- microtomography (ab), Knut Lindblom, Oct., 641
- pancreas visualization by right lateral sagittal tomograms after combined retro- and intraperitoneal gas insufflation (ab), H. Ludin, Nov., 813
- planigraphy in differential diagnosis of pulmonary nodule, with particular reference to notch sign of malignancy, Leo G. Rigler and E. Robert Heitzman, Nov., 692
- production of transverse tomogram and failures in positioning (ab), F. Hammer, Aug., 313
- rotation tomography at small angles (ab), Knut Lindblom, Nov., 823
- third international course on tomography, July, 115
- tomography of bronchi and of hilar regions in right posterior oblique projection (ab), Alberto Maestri, Nov., 798
- use of tomography in paramedial pleura following gas insufflation of mediastinum (ab), Graziano Pidone and Gaetano Cosentino, Nov., 804
- value of tomography for unexplained infiltrations in upper mediastinum of infants (ab), H. W. Kirchhoff, Aug., 294

BOECK'S SARCOID. See Sarcoidosis

BOGARDUS, GEORGE M., KNUDSTON, KENNETH P., and MILLS, WALDO H.: Pleural mesothelioma. Report of four cases (ab), Dec., 949

BOGEN, EMIL. See PERKINS, BLANCHE

BOGOROCH, RITA. See SOGNAES, REIDAR F.

BOLEMAN, AUSTIN, P., Jr., and BRESLAU, LEONARD: Primary malignancies of the papilla of Vater. Case report and review (ab), Oct., 636

BOLTON, BILLY F. See OVERTON, ROBERT C.

BOMPIANI, CARLO: Angiocardiographic findings in pulmonary tumors (ab), Nov., 807

BOND, V. P., SILVERMAN, M. S., and CRONKITE, E. P.: Pathogenesis and pathology of post irradiation infection (ab), Aug., 321

BONES

- See also Cranium; Spine; under names of bones
- disappearing bones: a rare form of massive osteolysis; 2 cases, 1 with autopsy findings (ab), L. W. Gorham et al., Sept., 474
- Ehlers-Danlos syndrome with ectopic bone formation, Isadore Katz and Karl Steiner, Sept., 352
- fate of radiopaque media injected into cancellous bone of extremities (ab), R. G. Harrison and H. H. Gossman, Dec., 955
- radiotracer studies on bone, cementum, dentin and enamel of Rhesus monkeys (ab), Reidar F. Sognnaes et al., Dec., 955
- studies of bone metabolism. I. A comparison of metabolism of strontium⁹⁰ in living and dead bone (ab), Robert D. Ray et al., Nov., 831

atrophy

- bone density measurements of osteoporosis in the aged, J. Gershon-Cohen, Harald Schraer and Nathan Blumberg, Sept., 416
- Sudeck's syndrome after fractures (ab), G. Bierling and D. Reisch, Nov., 815

cancer

- skeletal involvement in carcinoma of urinary bladder (ab), Denis E. Fletcher, Aug., 308

cysts

- bone cysts and osteoarthritis of hip (ab), Elvio Cecchi and Aligi Fiumicelli, Sept., 478

diseases. See also Leontiasis Ossium; Osteochondritis; Osteomyelitis; other headings under Bones

- familial metaphyseal dysplasia, Harold Feld, Robert A. Switzer, Morris W. Dexter and Edward M. Langer, Aug., 206

- hypercalciuria and metabolic bone disease (ab), Milton L. Rosenberg, Oct., 641

- Milkman's pseudofractures of ribs following extraperitoneal Ivalon pack, Samuel H. Cohen, Oct., 587

- new observation in case of hyperostotic osteopathy of Engelmann-Camurati (ab), H. Weingraber, Oct., 639

- radiating spicules, a non-specific sign of disease, Otto H. Grunow, Aug., 200

echinococcosis

- case (ab), David C. Kelsey and Harry F. Sproat, Oct., 637

fractures. See Fractures**fragility.** See Osteosclerosis fragilis**growth**

- metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. I. Familial metaphyseal dysplasia and craniometaphyseal dysplasia; their relation to leontiasis ossa and osteopetrosis; disorders of "bone remodeling" (ab), W. P. U. Jackson et al., Oct., 636

- metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. II. Multiple epiphyseal dysplasia; its relation to other disorders of epiphyseal development (ab), W. P. U. Jackson et al., Oct., 637

- metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. III. Progressive diaphyseal dysplasia (ab), W. P. U. Jackson et al., Oct., 637

- metaphyseal dysostosis; case (ab), J. A. P. Cameron et al., Sept., 475

marrow

- effects of irradiation of pelvis in patients with carcinoma of cervix uteri on iliac and sternal marrow and on peripheral blood (ab), Lucile W. Huttaff and Helen W. Belding, Dec., 967

- pathogenesis of bone marrow injury in rats subjected to total irradiation with fast electrons (15-mev Siemens betatron) (ab), R. Stodtmeister and M. Th. Fliedner, July, 136

- treatment of multiple myeloma with radioactive iodine and radioactive iodinated serum albumin, Joseph P. Kriss, Howard R. Bierman, Sydney F. Thomas, and Robert R. Newell, Aug., 241

necrosis. See Necrosis**osteomyelitis.** See Osteomyelitis**pathology**

- bone changes in trophic disorders of leg (ab), A. Jakob, Nov., 818

- rare case of bony form of Hodgkin's lymphogranuloma (ab), O. Soyka et al., Nov., 815

tuberculosis

- natural history of pleural effusion and orthopedic tuberculosis (ab), F. Harwood Stevenson, Dec., 949

- roentgen diagnosis of primary diaphyseal tuberculosis of long tubular bones (ab), A. Heidenblut, Nov., 818

tumors

- bone lesions in Kaposi's sarcoma (ab), Francesco Ronchese and Arthur B. Kern, July, 138

- massive preoperative irradiation in treatment of osteogenic sarcoma in children; preliminary report (ab), Kenneth C. Francis et al., Sept., 482

- primary reticular cell sarcoma, with emphasis on roentgen aspects, Theodore W. Wilson and David G. Pugh, Sept., 343

- significance of serum protein shifts in diagnosis (ab), Béla Gimes and Zoltán Szendrői, Sept., 475

wounds and injuries

- effect of pressure on healing of bone; experimental study (ab), Lee T. Ford and J. Albert Key, Sept., 475

BONMANN, K.-H. See HESS, P.

BOOK REVIEWS

Bacq, Z. M., and Alexander, Peter, editors. Radiobiology Symposium, Sept., 433

Bétoulières, P., and Latour, H. Le pneumostomatographie, Nov., 789

Boyd, George A. Autoradiography in Biology and Medicine, Aug., 286

Clark, George L. Applied X-Rays, Aug., 286

Davidoff, Leo M., and Epstein, Bernard S. The Abnormal Pneumoencephalogram, Aug., 283

Epstein, Bernard S. The Spine. A Radiological Text and Atlas, Nov., 789

Etter, Lewis E. Atlas of Roentgen Anatomy of the Skull, Dec., 940

Gebauer, Alfred, and Schaan, Alfred. Das transversale Schichtverfahren, Sept., 454

Hess, Walter. Operative Cholangiographie. Technik. Diagnostik. Praxis, Aug., 287

BOOK REVIEWS—*cont.*

- Hurly, A., and Böhm, F. Bronchus und Tuberkulose. Bronchioskopische und bronchographische Untersuchungen der Bronchien bei der Tuberkulose. Sept., 454.
- Leger, Lucien. Spléno-portographie. Étude radiologique et clinique de la circulation portale normale et pathologique. Exploration des organes sus-mésocoliques. Nov., 790.
- Lewis, Raymond W. The Joints of the Extremities. A Radiographic Study. Notes on Non-Routine Methods, Non-Routine Ideas, and Less-Common Pathology. Sept., 453.
- Meuwissen, T. J. J. H. X-Ray Atlas and Manual of Esophagus, Stomach and Duodenum. Aug., 285.
- Moore, Sherwood. Hyperostosis Cranii. Stewart-Morel Syndrome: Metabolic Craniopathy; Morgagni's Syndrome: Stewart-Morel-Moore Syndrome (Ritvo); Le Syndrome de Morgagni-Morel. Aug., 285.
- Olivier, Claude. Radio-diagnostic des occlusions intestinales aiguës. July, 117.
- Recommendations of the International Commission on Radiological Protection. Brit. J. Radiol. Supplement 6, Nov., 789.
- Ritvo, Max. Bone and Joint X-Ray Diagnosis. Oct., 615.
- Roux, Marcel. Les cancers du colon. Sept., 453.
- Stutz, Ernst, and Vieten, Heinz. Die Bronchographie. Sept., 455.
- Vogt, Alfred. Diagnostik und Strahlentherapie der Geschwulstkrankheiten. July, 116.
- BOOKS RECEIVED (not reviewed)**
- Anacker, H. Lungenkrebs und Bronchographie mit Untersuchungen über Ursprung und Ursprungsbedingungen des Bronchialkarzinoms. Dec., 940.
- Aubaniac, Robert, and Porot, Jacques. Radio-anatomie générale de la tête: 37 coupes anatomiques dans les trois plans de l'espace, dessinées, radiographiées et commentées. Dec., 940.
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- BORS, ERNEST, CONRAD, CHESTER A., and MASSELL, THEODORE B. Venous occlusion of lower extremities in paraplegic patients (ab), Aug., 300.
- See COMARR, A. ESTIN
- BOST, ROGER B. See SNYDER, C. HARRISON
- BOTKIN, A. L., ESKELSON, C. D., FIRSHIE, H. E., and JENSEN, H. L. In vitro studies of the intact thyroid gland (ab), Aug., 317.
- BOTSFORD, THOMAS W. See WHEELER, H. BROWNELL
- BOUCHARD, JEAN. See DUGGER, G. S.
- BOUCOT, KATHARINE R., CARNAHAN, WILLIAM, COOPER, DAVID A., NEALON, THOMAS, Jr., OTTENBERG, DONALD J., and THEODOS, PETER A. Philadelphia Pulmonary Neoplasm Research Project. Preliminary report (ab), Nov., 802.
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- BOWERS, JOHN Z. See DOUGHERTY, JEAN H.
- BOYARSKY, SAUL. Paraplegia following translumbar aortography (ab), Aug., 298.
- BOYD, DAVID P., SMEDAL, MAGNUS I., KIRTLAND, HOWARD B., Jr., KELLEY, GURNEY E., and TRUMP, JOHN G. Carcinoma of lung. A report of 403 cases (ab), Aug., 291.
- BOYD, J. W. An experience with the large routine chest film in a rural hospital (ab), Aug., 293.
- BOYD, JOSEPH A. See ABDULKERIM, ANIS
- BOYD, LINN J. See GLASS, GEORGE B. JERZY
- BRACE, K. C., ANDREWS, H. L., and THOMPSON, E. C. Early radiation death in guinea pigs (ab), Oct., 650.
- BRACHIAL PLEXUS**
- myelogram in avulsion of brachial plexus. Albert A. Rayle, Jr., Brit B. Gay, Jr., and Jason L. Meadors, July, 65.
- myelography to help localize traction lesions (ab), J. M. Tarlov and Robert Day, July, 141.
- BRACHYDACTYLISM.** See Fingers and Toes
- BRAESTRUP, C. B., and MOONEY, R. T.** Cobalt 60 protection design, Dec., 884.
- BRAIN**
- See also Cerebellum; Meninges; Pituitary Body; etc.
- distribution and pathology resulting from intracerebral and intraventricular injection of radioactive gold and silver coated radiogold colloids (ab), C. C. McClure, Jr., et al, Nov., 850.
- radiomicrography of autopsy brain. I. The normal pattern. Isadore Meschan, Charles S. Pool, Anderson Nettleship, Melvin Winer and Wolfgang Zeman, Nov., 770.
- abnormalities**
- posterior fossa cysts due to congenital atresia of foramina of Luschka and Magendie. (ab), M. Sofer Schreiber and R. D. K. Reye, Sept., 460.
- blood supply.** See also Brain, tumors
- carotid basilar anastomosis, with multiple associated cerebrovascular anomalies, case (ab), J. P. Schaerer, Nov., 795.
- complications of cerebral angiography (ab), Alberto D. Kaplan and A. Earl Walker, July, 125.
- oblique view in cerebral angiography (ab), Curwood R. Hunter and Frank H. Mayfield, Nov., 795.

BRAIN, blood supply—cont.

- percutaneous vertebral angiography (ab), Pierre Namin, July, 125
- rupture of an intracranial aneurysm during cerebral angiography (ab), Kenneth G. Jamieson, Sept., 459
- some complications of vertebral angiography (ab), Oscar Sugar and Paul C. Bucy, Sept., 459
- Triurol in cerebral angiography (ab), Sven Odén, Dec., 946
- vascular malformations in region of great vein of Galen (ab), Lyle A. French and William T. Peyton, July, 126

calcification

- roentgen findings and intracerebral calcifications in congenital toxoplasmosis (ab), J. François and Fr. De Witte, Nov., 796

necrosis

- following roentgen irradiation (ab), G. S. Dugger et al, Oct., 649

roentgenography. See also other subheads under Brain

- encephalographic study of normal morphology of occipital horns (ab), Sergio Chiappa, July, 125

- significance of negative neurosurgical diagnostic studies (ab), F. A. Martin et al, Oct., 625

surgery

- controlled transorbital leukotomy (ab), William A. Nosik, July, 126

tumors

- diagnosis of meningiomas within lateral ventricles (ab), A. E. Wall, Aug., 291

- encephalography. Review of 104 cases (ab), Giovanni Ruggiero et al, Nov., 795

- experimental effects of radioactive colloidal gold in subarachnoid space: clinical application in treating brain tumors (ab), Fred W. L. Kerr et al, Sept., 487

- new method of treatment of inoperable tumors by stereotaxic implantation of radioactive gold: preliminary report (ab), J. Talairach et al, Dec., 965

- oblique angiograms in diagnosis (ab), Guido Castorina, Nov., 795

- radioactive phosphorus in management (ab), Richard W. Garrity and LeRoy W. Matthews, Oct., 648

- simplified apparatus for tumor surveys (ab), Herbert C. Allen, Jr., and J. R. Risser, Nov., 827

- venographic clues to localization of intracranial masses (ab), Paul A. Riemschneider and Arthur Ecker, Sept., 459

wounds and injuries

- angiography in evaluation of intracranial trauma, J. E. Lofstrom, J. E. Webster, and E. S. Gurdjian, Dec., 847

- BRANSON, KATHARINE:** A case of incarcerated diaphragmatic hernia (ab), Dec., 954

- BRANT, EARL E.** See **SHERMAN, ROBERT S.**

- BRAUDO, J. LEONARD, NADAS, ALEXANDER S., RUDOLPH, ABRAHAM M., and NEUHAUSER, EDWARD B. D.:** Atrial septal defects in children. A clinical study with special emphasis on indications for operative repair (ab), Oct., 629

- BRAUSCH, CHARLES C.** See **MUELLER, RICHARD**

BREAST

- lymph drainage from breast to axillary and parasternal lymph nodes studied with aid of colloidal Au¹⁹⁸ (ab), K. A. Hultborn et al, Nov., 829

- neglected roentgenography of breast disease (ab), Jacob Gershon Cohen et al, Nov., 819

cancer

- (ed), July, 111

- carcinoma: influence of a febrile illness on arrested case (ab), Gwen Hilton, Aug., 315

- lymphangiosarcoma in postmastectomy lymphedema: 5-year survival with irradiation treatment (ab), Harry W. Southwick and Danely P. Slaughter, Nov., 823

- McWhirter technique for treatment: an appraisal (ab), Vincent P. Collins, Sept., 484

- method of preoperative roentgen therapy by high doses, followed by radical operation for carcinoma of breast (showing survivals up to 10 years) (ab), F. Baclesse, Nov., 823

- phlebographic study of swollen arm following radical mastectomy (ab), S. Schorr et al, Aug., 300

- problems in therapy (ab), R. Wanke, Dec., 959

- rationale and results of simple mastectomy plus radiotherapy in primary cancer (ab), L. H. Garland, Oct., 643

- use of colloidal Au¹⁹⁸ for detection of lymph nodes in radical excision of breast (ab), K. A. Hultborn and L. I. Jonsson, Dec., 963

- BRESLAW, LEONARD.** See **BOLEMAN, AUSTIN P., Jr.**

- BRESSON, R.** See **MOUNIER-KUHN, P.**

- BRICKER, EUGENE M., BUTCHER, HARVEY, and McAFEE, C. ALAN:** Late results of bladder substitution with isolated ileal segments (ab), Aug., 312

- BRICKER, NEAL S.** See **HLAD, CHARLES J., Jr.**

BRONCHI

- See also Bronchiectasis; Bronchitis

- contribution of roentgenology to diagnosis of syndromes caused by bronchial stenosis following adenopathy (middle lobe syndrome and analogous syndromes) (ab), Luigi Pigorini and Gaetano Tricomi, Dec., 947

- differentiation of benign bronchostenosis and its relation to atelectasis (ab), H. Finke, Dec., 947

- postoperative bronchopathies (ab), P. Mounier-Kuhn et al, Nov., 803

- time and site study for optimum lymph node concentration of radiogold following intrabronchial injection (ab), Harold F. Berg et al, Oct., 647

cancer. See also Lungs, cancer

- asymptomatic bronchogenic carcinoma (ab), Robert P. McBurney et al, Nov., 801

- bronchography in diagnosis of bronchogenic carcinoma in 2 patients with apparently normal chest films, Judah Zizmor, Dec., 868

- pneumomediastinum in bronchial cancer (ab), A. Balme and A. Thévenet, July, 127

roentgenography. See also Bronchiectasis; other subheads under Bronchi

- bilateral bronchography: new material (Dionosil oily) and technic, Cesare Gianturco and George A. Miller, July, 37

- bronchography: study of its technics and the presentation of an improved modification (ab), Kenneth L. Diehl, July, 126

- bronchography: technic and choice of contrast media (ab), Carl E. Gudbjerg, Sept., 462

- bronchography with Dionosil in pulmonary tuberculosis (ab), Conway Don, Nov., 800

- inflammatory changes in bronchial glands in chronic bronchitis, demonstrated bronchographically (ab), Carl E. Gudbjerg and Gregers Thomsen, Aug., 293

- occasional bronchography (ab), A. C. Glendinning, Nov., 798

- tomography of bronchi and of hilar regions in right posterior oblique projection (ab), Alberto Maestri, Nov., 798

- tracheographic and bronchographic studies as aids in diagnosis of congenital malformations of tracheobronchial tree and aortic arch in infants and children (ab), Charles F. Ferguson and Carlyle G. Flake, Oct., 628

tumors

- clinical survey of adenomas of trachea and bronchus in general hospital (ab), Lamar Soutter et al, Aug., 292

BRONCHIAL GLANDS. See Bronchitis**BRONCHIECTASIS**

- bronchiectasis—dextrocardia—sinusitis: a contribution to etiology of bronchiectasis (ab), Carl E. Gudbjerg, Oct., 628

- remarks on bronchiectasis with emphasis on bronchographic aspects (ab), Luigi Ciarpaglini and Giorgio Fusi, Dec., 948

BRONCHITIS

- inflammatory changes in bronchial glands in chronic bronchitis, demonstrated bronchographically (ab), Carl E. Gudbjerg and Gregers Thomsen, Aug., 293

BRONCHOGRAPHY. See Bronchi, roentgenography; Bronchiectasis**BROWN, FLORA, M., and AYE, RALPH C.:** Myelographic demonstration of the basilar artery (ab), Nov., 795**BROWN, RAY E.:** Chest surveys. The hospital administrator looks at chest surveys, July, 22**BROWN, W. M. COURT, and ABBATT, JOHN D.:** Effect of a single dose of x-rays on the peripheral blood count of man (ab), Nov., 832**BRUCE, W. R., and JOHNS, H. E.:** Investigation of grid fields with a miniature ionization chamber (ab), July, 150**BRUCER, MARSHALL:** Marble as a radiation shield (ab), Nov., 835**BRUNNER'S GLANDS. See Duodenum, tumors****BRUWER, ANDRÉ J., and KIERLAND, ROBERT R.:** Neurofibromatosis and congenital unilateral pulsating and non-pulsating exophthalmos (ab), Nov., 797**BRYANT, J. RAY.** See **BERG, HAROLD F.****BUCKLEY, HAROLD D.** See **RAY, ROBERT D.****BUCK, PAUL C.** See **GOKAY, HUSAMEDDIN****BUERKI, ROBIN:** Chest surveys. What the public thinks of chest surveys, July, 26**BULKLEY, GEORGE J., COOPER, JOHN A., and O'CONNOR, VINCENT J.:** Intraprostatic injections of radioactive colloids. II. Distribution within the prostate and tissue changes following injection in the dog (ab), July, 153**BULL, J. W.** See **CREGG, H. A.****BURCH, G. E.** See **RAY, C. T.****—See THREEFOOT, S. A.****BURKE, EDWARD N.** See **LEVENE, GEORGE****BURNETT, WILLIAM T., Jr.** See **FURTH, JACOB****BURNS**

- combined effects of thermal burns and whole-body x-irradiation. II. Anemia (ab), A. K. Davis et al, Sept., 488

- combined effects of total-body x-irradiation and radiant energy thermal burns on the osmotic and mechanical fragility of the erythrocyte (ab), E. L. Alpeu et al, Oct., 651

- use of radioactive sulfur labeled methionine in study of protein catabolism in burn patients (ab), T. G. Blocker, Jr. et al, Aug., 319

BURNS, EDGAR. See **HIDALGO, JOHN U.****BURROWS, B. A.** See **HINE, G. J.****BURT, L. IAN, and MASEL, H.:** Cholecystitis glandularis proliferans (diverticula of the gall bladder) (ab), Dec., 953**BUSH, W. LESLIE.** See **CLAYTON, R. S.****BUSHMAN, M.** See **FERLAZZO, G.****BUTANOL**

- clinical use of plasma butanol-extractable (thyroxin) ¹³¹I in diagnosis of hyperthyroidism and myxedema (ab), Alvin L. Schultz et al, July, 151

BUTCHER, HARVEY. See **BRICKER, EUGENE M.**

C

CADAVERS. See Autopsies

CADMIUM, RADIOACTIVE. See Radioactivity

CALCIFICATION

See also Aorta; Loiasis; Rectum; Spine; intervertebral disks; Stomach, cancer; etc.

—"in vivo" dissolution of metastatic calcium: an approach to atherosclerosis (use of EDTA) (ab), Norman E. Clarke et al., Dec., 957

CALCIUM. See Hand; Urine and Urination

CALCULI. See Bladder; Gallbladder; Kidneys

CALEB FISKE PRIZE, Rhode Island Medical Society, Nov., 787

CALVÉ'S DISEASE. See Osteochondritis deformans

CAMERON, J. A. P., YOUNG, W. B., and SISSONS, H. A.: Metaphysal dysostosis. Report of a case (ab), Sept., 475

CAMP, WALTER H.: Carcinoid of the stomach, Nov., 733

CAMPBELL, JOHN A., and SILVER, RICHARD A.: Roentgen manifestations of epidural granulomas of the spine, with a report of ten cases (ab), July, 141

CAMPBELL, MAURICE, and DEUCHAR, D. C.: The left-sided superior vena cava (ab), Aug., 297

CANCER

See also under names of organs; Tumors, experimental

—effects of antitumor drugs upon P^{32} incorporation into nucleic acids of mouse tumors (ab), Jack D. Davidson and Betty B. Freeman, Nov., 830

—grants-in-aid in cancer research, July, 114

chorionic

—spontaneous regression of pulmonary metastases of a chorio-epithelioma (ab), W. Rübe, Sept., 464

metastases. See also Bones, cancer; Lungs, cancer; Lymph

Nodes, cancer; Pleura, effusions

—testicular cancer, management of metastases, with report of a new chemotherapeutic agent (Nitrofurazone), Orliss Wildermuth, Oct., 599

radiotherapy

—experiences with use of radioactive colloidal gold (ab), H. Brownell Wheeler et al., Dec., 964

—future of rotation therapy: rotational irradiation of patients with deep-seated tumors (ab), D. W. Smithers, July, 149

—hypophysectomy with radioactive chromic phosphate in treatment of cancer (ab), Sanford F. Rothenberg et al., Dec., 965

—indication for moving beam therapy (ab), Jens Nielsen and B. Jorgsholm, July, 150

—investigation of grid fields with miniature ionization chamber (ab), W. R. Bruce and H. E. Johns, July, 150

—is rotation therapy with betatron of 15 to 31 mev energy advantageous? (ab), H. R. Schinz and R. Wideröe, July, 150

—moving field irradiation through a grid: new method of roentgen therapy (ab), H. Hiltmann, July, 150

—prophylaxis and palliation of malignant effusions with radioactive colloidal gold (ab), Irving I. Cowan and Frank G. Kariotis, Dec., 965

—radioactive isotopes in management of carcinomatosis of serous body cavities (ab), Edward M. Kent et al., July, 151

—technic for evaluating effectiveness of localization of radioactive colloidal gold-198 after direct injection into tumors (ab), John U. Hidalgo et al., Aug., 318

CANDARJIS, G., and SAEGESSER, F.: Microcolon and meconium ileus (ab), Sept., 471

CANNON, JACK A. See GONZALEZ, RUDOLPH M.

CANTRIL, SIMEON T.: Radiation therapy in management of the lymphomas (ab), Sept., 484

CARAVATI, CHARLES M., and MacMILLAN, JAMES M.: Venography in the diagnosis of the Cruveilhier-Baumgarten syndrome (ab), Sept., 467

CARBON, RADIOACTIVE. See Radioactivity

CARBOXYMETHYLCELLULOSE

—foreign body granulomas following hysterosalpingography with contrast medium containing carboxymethylcellulose (ab), F. Bergman et al., Nov., 821

CARCINOID. See Stomach, cancer

CARD, RICHARD Y., and STRACHMAN, JEROME: Congenital ankylosis of the elbow (ab), Nov., 817

CARD, WILLIAM H. See BANKER, ROBERT J.

CARDIA. See Stomach

CARDIOANGIOGRAPHY. See Heart, roentgenography

CARDIOSPASM. See Stomach

CARDIOVASCULAR SYSTEM

See also Aorta; Arteries; Heart; etc.

—effect of total-body x-irradiation on serum electrolyte levels and electrocardiograms of golden hamster (ab), George P. Fulton and Frederick N. Sudak, Aug., 322

—gargoylism with cardiovascular involvement in two brothers (ab), R. W. Emanuel, Aug., 295

roentgenography

—angiocardigraphic findings in pulmonary tumors (ab), Carlo Bompiani, Nov., 807

—angiocardigraphy: a guide to mediastinal exploration (ab), Stanley M. Wyman, Aug., 295

—interpretation of low (cardiac) arches of cardiovascular roentgen silhouette in oblique views (ab), Jorge Meneses Hoyos and José Araújo, Aug., 295

—new 12 X 12-inch roll film magazine for rapid serial roentgenography, Israel Steinberg, William Dubilier and John A. Evans, Aug., 276

—photofluorographic detection of cardiovascular disease in a general hospital (ab), Harold D. Batt et al., Oct., 629

—study of clinical reactions to venous angiocardigraphy (ab), Frederic L. Eldridge et al., Dec., 950

—value of selective angiocardigraphy in diagnosis of complete transposition of great vessels (ab), Åke Gyllenswärd and Herman Lodin, July, 127

CARLSON, RALPH F. See LALLI, ANTHONY

CARNAHAN, WILLIAM. See BOUCOT, KATHARINE R.

CARNES, WILLIAM H. See KRISSE, JOSEPH P.

CAROTHERS, E. L. See McCLURE, C. C., Jr.

CARROLL, ROBERT E., SINTON, WILLIAM, and GARCIA, ALEXANDER: Acute calcium deposits in the hand (ab), Nov., 817

CARROLL, W. H. See HOLOUBEK, JOE

CARSON, MERL J. See SOBIN, SIDNEY S.

CARTILAGE. See Nose

CARTWRIGHT, G. E. See WINTROBE, M. M.

CASTELLANO, FRANCESCO. See RUGGIERO, GIOVANNI

CASTORINA, GUIDO: Oblique angiograms in the diagnosis of cerebral tumors (ab), Nov., 795

CATABOLISM. See Proteins

CATALANO, D., and RICCIO, S.: Visualization of gastric and lower esophageal veins by splenoportography in a case of carcinoma of the lesser curvature (ab), July, 130

CATARACT

—production of cataracts in animals by x-rays and fast neutrons, P. J. Leinfelder, T. C. Evans and E. Riley, Sept., 433

CATHARTICS

—roentgen abnormalities of large and small intestine associated with prolonged cathartic ingestion, Norman Heilbrun and Charles Bernstein, Oct., 549

CATZ, BORIS. See STONE, HERMAN

CAULK, RALPH M.: Transvaginal roentgen therapy in cancer of the cervical stump (ab), July, 147

CAUMARTIN, HUGH. See SHERMAN, ROBERT S.

CAVE, A. J. E., GRIFFITHS, J. D., and WHITELEY, M. M.: Osteo-arthritis deformans of the Luschka joints (ab), Nov., 816

CAVOGRAPHY. See Venae Cavae

CECCHI, ELVIO, and FIUMICELLI, ALIGI: Bone cysts and osteoarthritis of the hip (ab), Sept., 478

CECUM

volulus. See Intestines, volvulus

CELIAC DISEASE

—roentgen studies of small intestine in sprue (ab), Richard H. Marshak et al., July, 131

CELLS

—cytochemical changes in lymph nodes and spleen of rats after total-body x-radiation (ab), G. Adolph Ackerman et al., July, 156

—problem of radioresistance in biology and medicine (ab), G. Schubert, Dec., 968

CEMENTUM. See Teeth

CEPHALOGRAPHY. See Cranium

CEPHALOMETRY. See Craniometry

CERATI, MARIO: Transpyloric prolapse of the gastric mucosa (ab), Sept., 468

CEREBELLUM

—pneumographic aspect of angioreticuloma (hemangioblastoma) of cerebellum (ab), Giovanni Ruggiero and Francesco Castellano, Oct., 625

CEREBRUM. See Brain

CESIUM, RADIOACTIVE. See Radioactivity

CHAMBERLAIN, EICHARD H. See LEWIS, GEORGE C., Jr.

CHAMBERS, WILLIAM R.: Acute occlusion of the internal carotid artery. Report of five cases (ab), Sept., 459

Diastematomyelia. Report of a case diagnosed preoperatively (ab), Oct., 639

Headache as the first and only sign of basilar impression (ab), Nov., 796

X-ray demonstrable lesions in occipital headache (ab), Aug., 291

CHANUTIN, ALFRED, and WORD, ELIZABETH L.: Effect of hydroxylamine and x-irradiation on red cell destruction and formation and serum iron concentration (ab), Oct., 652

CHAPMAN, WILLIAM P., WYMAN, STANLEY M., GAGNON, JACQUES, JONES, CHESTER M., and PULIO, GRACE L.: Gastrointestinal motility in man. Influence of a standard meal on the effect of Banthine (ab), Oct., 634

CHARTERIS, ALEXANDER A.: Radium treatment of squamous carcinoma in cervical lymphatic nodes (ab), Aug., 315

CHAUSS, JAY M.: Chondroectodermal dysplasia (Ellis-van Creveld disease). A case report, Aug., 213

CHENG, C. S. See YANG, SZE-PIAO

CHEST. See Thorax

CHIAPPA, SERGIO: Encephalographic study of the normal morphology of the occipital horns (ab), July, 125

CHILDREN

See also Heart, abnormalities; Infants, Newborn; Intussusception

—calcification of intervertebral disks in children (ab), C. S. Walker, Sept., 477

—diagnostic transabdominal pneumoperitoneum in children (ab), Ralph H. Kunstader and Alex Tulskey, July, 142

—gastrointestinal distention in infants (ab), Alex Gerber, Nov., 809

CHILDREN—cont.

- hypertension in infancy, with anomalous renal artery: diagnosis by renal arteriography, apparent cure after nephrectomy (ab), C. Harrison Snyder et al, Nov., 808
- massive preoperative irradiation in treatment of osteogenic sarcoma in children; preliminary report (ab), Kenneth C. Francis et al, Sept., 482
- neuromuscular disorders of the urinary tract in children, R. Parker Allen, Sept., 325
- obstruction of small intestine in infants and children: roentgenologic and pathologic study (ab), Richard M. Craig et al, July, 131
- ossifying fibromas (fibrous dysplasia) of facial bones in children and adolescents (ab), Nicholas Georgiade et al, Nov., 796
- peptic ulcer in children (ab), Leslie L. Lemak et al, Sept., 469
- pneumatosis cystoides intestinalis in infancy (ab), Leonard Paris, Nov., 810
- roentgen examination of proximal femur end in children and adolescents: a standardized technic also suitable for determination of the collum-, anteversion-, and epiphyseal angles. A study of slipped epiphysis and coxa plana (ab), Lars Billing, July, 140
- roentgenologic aspects of chronic ulcerative colitis in children, John R. Hodgson and Roger L. J. Kennedy, Nov., 671
- technic for roentgenographic examination of newborn, premature, or ill infants without removal from incubator (ab), Henry K. Silver and William L. Nyhan, Oct., 641
- tension emphysema; surgical emergency in infants (ab), T. Y. Nelson and Douglas Reye, Aug., 292
- tracheographic and bronchographic studies as aids in diagnosis of congenital malformations of tracheobronchial tree and aortic arch in infants and children (ab), Charles F. Ferguson and Carlyle G. Flake, Oct., 628
- treatment of hemangioma of skin in infancy and childhood by roentgen irradiation and radium; 323 cases (ab), Anis Abdulkadir et al, Sept., 482
- urinary tract calculi in children: renal and vesical calculi in 8-month-old child (ab), C. A. Moore and C. C. Dodson, Oct., 640
- use of tomography for unexplainable infiltrations in upper mediastinum of infants (ab), H. W. Kirchhoff, Aug., 294
- CHILKO, ALEXANDER J.** See **HOFFMANN, KARL F.**
- CHLORIDES**
 - studies on excretion of chloride by man with and without congestive heart failure, using long-life radiochloride, ^{36}Cl (ab), C. T. Ray et al, Sept., 486
- CHLORPROMAZINE HYDROCHLORIDE**
 - observations on use of chlorpromazine hydrochloride in radiation sickness (ab), D. O'Connell, Nov., 834
- CHOLANGIOGRAPHY.** See Biliary Tract
- CHOLECYSTECTOMY.** See Biliary Tract; Gallbladder
- CHOLECYSTITIS.** See Gallbladder
- CHOLECYSTITIS GLANDULARIS PROLIFERANS.** See Gallbladder, diverticula
- CHOLECYSTOCHOLANGIOGRAPHY.** See Biliary Tract
- CHOLECYSTOGRAPHY.** See Gallbladder
- CHOLEDOCHUS.** See Bile Ducts
- CHOLOGRAPHIN.** See Biliary Tract
- CHORIOEPITHELIOMA.** See Cancer, chorionic
- CHRISTENBERRY, K. W.** See **ROOT, GROSVENOR T.**
- CHRISTENSEN, BURT H.** See **ROOT, GROSVENOR T.**
- CHRISTENSEN, W. R.** See **ARONS, WALTER L.**
- CHRISTOPHERSEN, WILLIAM M.** See **BERG, HAROLD F.**
- CHROMIUM, RADIOACTIVE.** See Radioactivity
- CHU, FLORENCE C. H.** See **SHERMAN, ROBERT S.**
- CHYLOTHORAX**
 - chylothorax (chyloptoe) with pseudomiliary lesions in lungs; case (ab), W. Löffler and G. Jaccard, Sept., 464
- CIARPAGLINI, LUIGI, and FUSI, GIORGIO:** Remarks on bronchiectasis with emphasis on bronchographic aspects (ab), Dec., 948
- CICATRIX.** See Bladder, stricture
- CIMMINO, CHRISTIAN V.:** Gastric adenomyosis vs. aberrant pancreas, July, 73
- CINERADIOGRAPHY**
 - cinemicrographic observations and theoretical considerations on reactions of lymphocytes to x-rays, Robert Schrek, Dec., 912
 - practical image amplifier techniques: fluoroscopy, cinefluorography, spot-film radiography and use with closed circuit television, Herbert M. Stauffer, Morton J. Oppenheimer, George H. Stewart III, and Archie W. Blackstone, Nov., 784
- CIRCULATION.** See Brain, blood supply; Extremities; etc.
- CISTERNA CHYLI.** See Thoracic Duct
- CLARK, CARL W., Jr.:** Operative cholangiography. Survey of present day opinions (ab), Aug., 306
- CLARKE, CHARLES N.** See **CLARKE, NORMAN E.**
- CLARKE, NORMAN E., CLARKE, CHARLES N., and MOSHER, ROBERT E.:** The "in vivo" dissolution of metastatic calcium. An approach to atherosclerosis (ab), Dec., 957
- CLAYTON, R. S., GOODMAN, PAUL H., and BUSH, W. LESLIE:** Common hazards of x-ray diagnosis in urologic practice: their recognition and reduction (ab), July, 155
- CLEIN, NORMAN W.:** How safe is x-ray and fluoroscopy for the patient and the doctor? (ab), July, 155
- CLEMEDSON, CARL-JOHAN, and NELSON, ARNE:** Effects of combined whole body roentgen irradiation and high explosive blast injury in mice (ab), Dec., 908
- CLOUTIER, J. A. R.** See **STEPHENS-NEWSHAM, L. G.**
- CLYMER, ROBERT H., Jr.** See **IMBER, IRVING**
- COARCTATION.** See Aorta; Arteries, pulmonary
- COBALT, RADIOACTIVE.** See Radioactivity
- COCCIDIOIDOMYCOSIS**
 - chronic coccidioid synovitis of knee joint (ab), Federico Sotelo-Ortiz, Nov., 818
 - pulmonary coccidioidomycosis; roentgen aspects of 500 cases (ab), J. W. Birsner, Aug., 292
- CODE, CHARLES F.** See **SCHOLER, JOHN F.**
- COHEN, HAROLD H.:** Unusual bone regeneration in Pott's disease (ab), July, 139
- COHEN, OSCAR H.:** Limy ductus choledochus, July, 78
- COHEN, SAMUEL L.:** Milkman's pseudofractures of the ribs following extraperiosteal Ivalon pack, Oct., 587
- COHN, EDWIN M., ORLOFF, THEODORE L., SKLAROFF, DAVID M., and GERSHON-COHEN, JACOB:** Use of Cholografin in the postcholecystectomy syndrome (ab), Nov., 812
- COLCOCK, BENTLEY P., and SASS, ROBERT E.:** Diverticulitis and carcinoma of the colon. Differential diagnosis (ab), Sept., 471
- COLD**
 - biological modification of effects of roentgen rays. I. Reduced temperature (ab), Frederick M. Allen, Nov., 833
- COLE, LEONARD J., and ELLIS, MARIE:** Spleen desoxyribonucleic acid content as an index of recovery in x-radiated mice treated with spleen homogenate (ab), Sept., 488
- See **EPSTEIN, A. A.**
- COLECTOMY.** See Colon
- COLEY, BRADLEY L., and HIGINBOTHAM, NORMAN L.:** Management of malignant disease in the neighborhood of the hip (ab), Oct., 643
- See **FRANCIS, KENNETH C.**
- COLITIS**
 - ulcerative
 - perforation of colon (ab), Charles B. Ripstein, Oct., 636
 - roentgenologic aspects of chronic ulcerative colitis in children. John R. Hodgson and Roger L. J. Kennedy, Nov., 671
- COLLAGEN**
 - collagenous changes in intervertebral disk with age and their effect on its elasticity: an x-ray crystallographic study (ab), A. Naylor et al, July, 139
- COLLER, FREDERICK A., and REGAN, WILLIAM J.:** Difficulties of diagnosis of some lesions of colon (ab), Aug., 303
- COLLINS, VINCENT P.:** McWhirter technique for treatment of breast cancer. An appraisal (ab), Sept., 484
- COLON**
 - See also Colitis; Fistula; Intestines; Sigmoid
 - abnormalities**
 - microcolon and meconium ileus (ab), G. Candardjis and F. Saegesser, Sept., 471
 - cancer**
 - diverticulitis and carcinoma of colon: differential diagnosis (ab), Bentley P. Colcock and Robert E. Sass, Sept., 471
 - extrinsic deformities of colon mimicking carcinoma: 3 cases (2 due to adherence of epiploic appendix, 1 due to band of fibrous adhesions encircling right colon and ileum) (ab), Robert C. Overton et al, Sept., 471
 - diseases**
 - difficulties of diagnosis of some lesions (ab), Frederick A. Collier and William J. Regan, Aug., 303
 - mucous colon, Maxwell H. Poppel, H. Adler, Harold G. Jacobson, J. Stein and L. R. Lawrence, July, 50
 - diverticula.** See Epiploic Appendages; Intestines, diverticula
 - fistula.** See Fistula
 - perforation**
 - in ulcerative colitis (ab), Charles B. Ripstein, Oct., 636
 - roentgenography.** See Intestines, roentgenography; other subheads under Colon
 - surgery**
 - ileum following colectomy, Samuel H. Madell and Ross Golden, Oct., 539
 - tumors**
 - detection of small lesions of large bowel: barium enema versus double contrast (ab), J. Maurice Robinson, Sept., 470
 - volvulus.** See Intestines, volvulus
- COLOSTOMY**
 - pathogenesis of intestinal ulcers following irradiation: effects of colostomy and adhesions (ab), Nathan B. Friedman, Nov., 831
- COLWELL, BRUCE T.:** Malignant duodenal colic fistula. Case report (ab), July, 132
- COMARR, A. ESTIN:** Renal changes in paraplegia as screened by routine excretory urography (ab), Aug., 311
- and **BORS, ERNEST:** Spermatozoostography in patients with spinal cord injuries (ab), Nov., 822
- COMBÉE, B.** See **SCHOLTE, P. J. L.**
- COMFORT, MANDRED W., GRAY, HOWARD K., DOCKERTY, MALCOLM B., GAGE, ROBERT P., BERGER, GEORGE R., SOLIS, JORGE, EPPERSON, DEAN P., and McNAUGHTON, ROBERT A.:** Small gastric cancer (ab), Aug., 301
- COMMISSUROTOMY.** See Mitral Valve
- COMPERE, EDWARD L., JOHNSON, WILLIAM E., and COVENTRY, MARK B.:** Vertebra plana (Calvé's disease) due to eosinophilic granuloma (ab), Aug., 307

- CONCRETE**
—radon released from concrete in radiant heating (ab). A. F. Gabrysh and F. J. Davis, Nov., 835
—x-ray attenuation in lead, aluminum, and concrete in the range 275 to 525 kilovolts, William Miller and R. J. Kennedy, Dec., 920
- CONRAD, CHESTER A.** See BORS, ERNEST
- CONTRAST MEDIA**
See also Barium; Iodine and Iodine Compounds; Gall-bladder, roentgenography; Zirconium; etc.
—fate of radiopaque media injected into cancellous bone of extremities (ab). R. G. Harrison and H. H. Gossman, Dec., 955
- CONVERSE, JOHN M.** See SHAPIRO, HARRY H.
- CONWAY, HERBERT, and STARK, RICHARD B.:** Arterial vascularization of the soft tissues of the hand (ab), Oct., 632
- COOLEY, ROBERT N.** See McKUSICK, VICTOR A.
- COOPER, DAVID A.** See BOUCOT, KATHARINE R.
- COOPER, JOHN A.** See BULKLEY, GEORGE J.
- COPELEY, ALFRED L., and STEFKO, PAUL L.:** Hemostasis in symp-thectomized and adrenalectomized animals before and after total body x-irradiation (ab), Oct., 651
- COR PULM.** See Heart, dilatation
- CORMACK, D. V.** See JOHNS, H. E.
- CORNATZER, W. E., DAVISON, J. P., ENGELSTAD, O. D., and SIMONSON, CAROL:** Effect of whole-body x-irradiation on lipids in the liver, kidney, and spleen of fasted rats (ab), Nov., 832
- CORNEA**
—treatment with new Lilliput roentgen tube (ab). P. J. L. Scholte et al., Aug., 316
- CORNFIELD, JEROME.** See SMITH, WILLIE W.
- CORONARY SINUS.** See Heart
- CORONARY VESSELS**
—hernia through esophageal hiatus simulating coronary pain; 50 cases (ab). Joe Holoubek et al., Nov., 813
—radiologic visualization in living subject; results of 413 observations (ab). Lucio Di Guglielmo and Mario Gutta-dauro, Nov., 806
- CORROSIVES**
—stenosis of esophagus and stomach following ingestion of corrosive substances (ab). Byron G. McKibben and Samuel Lee, Nov., 809
- CORSCADEN, JAMES A., and TOVELL, HAROLD M. M.:** The management of carcinoma of the corpus (ab), July, 147
- CORTATE.** See Adrenocortical Preparations
- CORTISONE.** See Adrenocortical Preparations
- COSENTINO, GAETANO.** See PIDONE, GRAZIANO
- COSTOLOW, WM. E., and WISDOM, WM. R.:** Radiation therapy in retroperitoneal tumors (ab), Dec., 960
- COUNTERS**
—distribution of radiiodine observed in thyroid disease by means of Geiger counters—its determination and significance (ab). J. P. Nicholson et al., Sept., 486
—Geiger counter probe for diagnosis and localization of posterior intraocular tumors (ab). Charles I. Thomas et al., July, 154
—K-9: a large 4x gamma-ray detector (ab). M. A. Van Dilla et al., July, 154
—near surface measurements of small gamma emitters by cadmium-sulfid crystal-probe (ab). R. Plesch and A. Schaal, Nov., 826
—scintillation counting for multiple-tracer studies (ab). G. J. Hine et al., Dec., 966
—studies with radiiodine. IV. Collimating cones for crystal counters, Earl R. Miller and Norman E. Scofield, July, 96
—surface scintillation measurements in humans of uptake of parentally administered radioactive vitamin B₁₂ (ab). George B. Jerzy Glass et al., Dec., 966
- COVENTRY, MARK B.** See COMPERE, EDWARD L.
- COWAN, IRVING I., and KARIORIS, FRANK G.:** Prophylaxis and palliation of malignant effusions with radioactive colloidal gold (ab), Dec., 965
- COWING, RUSSELL F., and DeAMICIS, EGILDA:** Suggested procedure for performance of autopsies on radioactive cadavers (ab), Aug., 319
- COX, ROBERT:** Radiotherapy in malignant disease of the testicle and penis (ab), Oct., 645
- COXA PLANA.** See Osteochondritis deformans juvenilis
- COXA VAKA.** See Hip
- CRAIG, RICHARD M., HODGSON, JOHN R., and DOCK-ERTY, MALCOLM B.:** Obstruction of the small intestine in infants and children. A roentgenologic and pathologic study (ab), July, 131
- PUGH, DAVID G., and SOULE, EDWARD H.:** The roentgenologic manifestations of synovial sarcoma, Dec., 837
- CRANE, AUGUST W., 1868-1937.** Howard P. Doub, July, 3
- CRANE, JACKSON F.** See KEATS, THEODORE E.
- CRANIOMETRY**
—orthostereoradiography in obstetrics: precision method for cephalopelvimetry (ab). Teodoro Flores Covarrubias, Aug., 309
- CRANIUM**
See also Craniometry
—cephalographic diagnosis in surgical treatment of malformations of face (ab). Harry H. Shapiro and John M. Converse, Oct., 626
- abnormalities**
—early recognition of premature synostosis, John W. Hope, Eugene B. Spitz and Harry W. Slade, Aug., 183
—metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. I. Familial metaphyseal dysplasia and craniometaphyseal dysplasia; their relation to leontiasis ossea and osteopetrosis; disorders of "bone remodeling" (ab). W. P. U. Jackson et al., Oct., 636
- cysts**
—posterior fossa cysts due to congenital atresia of foramina of Luschka and Magendie (ab). M. Sofer Schreiber and R. D. K. Reye, Sept., 460
- tuberculosis**
—roentgenological and pathological aspects (ab). José P. Tirona, Sept., 461
- CRASTNOPOL, PHILIP, HOCHBERG, LEW A., and KROOP, IRVING G.:** Surgical correction of eventration of diaphragm in patient with arthrogyposis. Observations on cardiac manifestations of traction on diaphragm (ab), Nov., 813
- CRAWFORD, T., DENT, C. E., LUCAS, P., MARTIN, N. H., and NASSIM, J. R.:** Osteosclerosis associated with chronic renal failure (ab), Nov., 814
- CREGG, H. A., SMITH, P. W., WILSON, C. W., and BULL, J. W.:** Cardioangiography, Sept., 368
- See SMITH, PHILIP W.
- CRETINISM**
—metabolism of iodine in 2 goitrous cretins compared with that in 2 patients receiving methimazole (ab). John B. Stanbury et al., Nov., 828
- CROCKITE, E. P.** See BOND, V. P.
- CROSBIE, STANLEY.** See LEVINE, MORRIS H.
- CROWLEY, LEONARD V.** See SHIPP, JOSEPH C.
- CRUTCHLOW, EVERETT F.:** The radiologist and athletic injuries (ab), Oct., 638
- CRUVEILHIER-BAUMGARTEN SYNDROME**
—venography in diagnosis of Cruevilhier-Baumgarten syndrome (ab). Charles M. Caravati and James M. MacMillan, Sept., 467
- CRYPTOCOCCOSIS.** See Torulosis
- CULVER, GORDON J., BEAN, BERTEN C., and BERENS, DAVID L.:** Gastric lymphoma, Oct., 518
- CUNNINGHAM, R. M.** See POCHIN, E. ERIC
- CYCLOTRON.** See Neutrons
- CYSTEAMINE**
—protective effect of cysteamine on young mice exposed to roentgen rays (ab). Arne Nelson, Oct., 652
- CYSTINE, RADIOACTIVE.** See Radioactivity
- CYSTS.** See Bones; Cranium; Duodenum; Intestines; etc.
- D**
- DAHL, O.** See BENNER, S.
- DAILEY, MORRIS E.** See LINDSAY, STUART
- See MILLER, EARL R.
- DANIEL, P. M., PRICHARD, MARJORIE M. L., and WARD-McQUAID, J. N.:** An angiographic study of the renal circulation in experimental hypertension in the dog (ab), July, 143
- DARGEON, HAROLD W.** See MERMANN, ALAN C.
- DAVID, M.** See RUGGIERO, GIOVANNI
- See TALAIRACH, J.
- DAVID ANDERSON-BERRY MEDAL, Dec., 939**
- DAVIDSON, JACK D., and FREEMAN, BETTY B.:** The effects of antitumor drugs upon P³² incorporation into nucleic acids of mouse tumors (ab), Nov., 830
- DAVIS, A. K., ALPEN, E. L., and SHELINE, G. E.:** The combined effects of thermal burns and whole-body x-irradiation. II. Anemia (ab), Sept., 488
- See ALPEN, E. L.
- DAVIS, F. J.** See GABRYSH, A. F.
- DAVIS, H. W.** See BACHMAN, C. H.
- DAVISON, J. P.** See CORNATZER, W. E.
- DAWSON, JOHN, and MITCHELL, P. R.:** Value of radiology in antepartum haemorrhage (ab), Sept., 480
- DAY, ROBERT.** See TARLOV, I. M.
- DeAMICIS, EGILDA.** See COWING, RUSSELL F.
- DEASY, J. B.** See MANN, BERTRAM
- DEBLEY, VIRGINIA.** See DETRICK, LAWRENCE E.
- DeGINDER, W. L.:** Osteochondritis dissecans of the talus, Oct., 590
- DEMAREST, HOWARD L.** See SCHULTZ, ALVIN L.
- DENENHOLZ, EDWARD J., and FEHER, GEORGE S.:** Barium reduction of intussusception in infancy (ab), Nov., 811
- DENHAM, SAM W.** See FORAKER, ALVAN G.
- DENST, JOHN.** See KUKRAL, ALBERT J.
- DENT, C. E.** See CRAWFORD, T.
- DENT, JAMES N.** See FURTH, JACOB
- DENTIN.** See Teeth
- DE ROUGE MONT, J.** See MOUNIER-KUHN, P.
- DESIOXYRIBONUCLEIC ACID**
—spleen desioxyribonucleic acid content as index of recovery in x-irradiated mice treated with spleen homogenate (ab). Leonard J. Cole and Marie Ellis, Sept., 488
- DETAR, JOHN H., and HARRIS, JAMES A.:** Venous pooled nephrograms: technique and results (ab), Sept., 481
- DETRICK, LAWRENCE E., UPHAM, HARVEY C., HIGHBY, DOROTHY, DEBLEY, VIRGINIA, and HALEY, THOMAS J.:** Effect of x-irradiation on gastric secretion and the accompanying gross and histological changes in the "Shay" rat stomach (ab), Oct., 651

- DEUCHAR, D. C.** See **CAMPBELL, MAURICE**
- DEVIK, FINN:** A study of the local roentgen reaction on the skin of mice, with special reference to the vascular effects (ab), Oct., 650
- DE WITTE, FR.** See **FRANÇOIS, J.**
- Dexter, MORRIS W.** See **FELD, HAROLD**
- Dextrocardia.** See Heart
- DIABETES, PHOSPHATIC.** See Phosphorus and Phosphorus Compounds
- DIAGNOSIS.** See Radioactivity; Roentgen Rays; under names of diseases and organs
- DIAPHRAGM**
See also Hernia, diaphragmatic
—deformity of left hemidiaphragm from a retothelial sarcoma of spleen (ab), Mario Rossetti, July, 135
—roentgenologic demonstration and analysis of diaphragm and of esophageal foramen (ab), J. Eberl, July, 136
—surgical correction of eventration in patient with arthrogryposis; observations on cardiac manifestations of traction on diaphragm (ab), Philip Crastopol et al., Nov., 813
- DIASTEMATOMYELIA.** See Spinal Cord, abnormalities
- DIATHERMY**
—study of effect of high temperature by hot baths, short waves and ultrasonics on cancer tissue and biological principles of combined x-ray-ultrasonics therapy of superficial tumors (ab), Karlheinz Woerber, Sept., 488
- DI CARLO, CLAUDIO:** Two cases of gastro-gastric intussusception (ab), July, 130
- DICK, D. R., HERRMANN, R. W., FERGUSON, CHARLES, and HEBERT, C. L.:** The use of a short acting, muscle relaxant drug (succinylcholine chloride) in diagnostic urography: a preliminary report (ab), Oct., 640
- DIECKMANN, W. J., and HARROD, J. P., Jr.:** Tubal ligation (sterilization) by a modified Madlener method (ab), July, 142
- DIEHL, KENNETH L.:** Bronchography. A study of its techniques and the presentation of an improved modification (ab), July, 126
- DIGESTIVE SYSTEM.** See Gastrointestinal Tract; Intestines; Stomach; etc.
- DI GUGLIEMMO, LUCIO, and GUTTADAURO, MARIO:** Radiological visualization of the coronary arteries in the living subject. Results of 413 observations (ab), Nov., 806
- DILLON, JOHN B.:** Fires and explosions in anesthesia, July, 108
- DIONOSIL.** See Bronchi
- DISCOGRAPHY.** See Spine, intervertebral disks
- DIVERTICULA.** See Duodenum; Intestines; Kidneys; Sigmoid
- DIVERTICULOMA.** See Sigmoid, diverticula
- DNA.** See Desoxyribonucleic Acid
- DOBYNS, BROWN M.** See **BEUVA, RICHARD S.**
- DOCKERTY, MALCOLM B.** See **COMFORT, MANDRED W.**
- DOE, CRAIG, RICHARD M.**
- DODDS, J. R., and LATOUR, J. P. A.:** Carcinoma of the cervical stump (ab), Dec., 960
- DODSON, C. C.** See **MOORE, C. A.**
- DOE, SOANES, WARD A.**
- DON, CONWAY:** Bronchography with Dignosil in pulmonary tuberculosis (ab), Nov., 800
- DORNBURGER, GEORGE R.** See **COMFORT, MANDRED W.**
- DORNEY, E. R., FOWLER, N. O., and MANNIX, E. P.:** Unilateral clubbing of the fingers due to absence of the aortic arch (ab), Nov., 806
- DOSIMETRY**
See also Radium; Roentgen Therapy
—film badge dosimetry: how much fading occurs? (ab), William L. McLaughlin and Margaret Ehrlich, Aug., 321
- DOUB, HOWARD P.:** Dr. Augustus W. Crane: 1868-1937, July, 3
- DOUGHERTY, E. F.** See **SALOMON, A.**
- DOUGHERTY, JEAN H., BOWERS, JOHN Z., BAY, ROBERT C., and KEYANONDA, PANIT:** Comparison of hematologic effects of internally deposited radium and plutonium in dogs, Aug., 253
- DOWNES, CHARLES R., HOPEMAN, ALAN R., TODD, WILLIAM A., Jr., and MATHEWSON, CARLETON, Jr.:** Aneurysm of splenic artery (ab), Dec., 951
- DRAMAMINE**
—effect of Cortate and of Dramamine on a selected group of patients undergoing deep roentgen therapy for carcinoma of cervix uteri (ab), E. C. Lasser and K. W. Stenstrom, Sept., 487
- DREWRY, GARTH.** See **JACKSON, W. P. U.**
- DRUGS**
See also Cathartics; Fallopian Tubes, tuberculosis (antibiotics); under names of drugs
—effects of antitumor drugs upon P^{32} incorporation into nucleic acids of mouse tumors (ab), Jack D. Davidson and Betty B. Freeman, Nov., 830
- DUBILIER, WILLIAM, Jr., TAYLOR, THOMAS L., and STEINBERG, ISRAEL:** Aortic sinus aneurysm associated with coarctation of the aorta (ab), Nov., 805
- See **STEINBERG, ISRAEL**
- DUCTUS ARTERIOSUS**
—syndrome of patent ductus arteriosus with reversal of flow (ab), Daniel S. Lukas et al., July, 128
- DUGGER, G. S., STRATFORD, J. G., and BOUCHARD, JEAN:** Necrosis of the brain following roentgen irradiation (ab), Oct., 649
- DUNN, J. HARTWELL.** See **KALMON, EDMOND H.**
- DUNNE, E. F.** See **PORTMANN, U. V.**
- DUODENUM**
—gastroduodenal intussusception, Howard Mauthe and George Zwicky, July, 86
—insulin-induced hypermotility in roentgen examination of stomach and duodenum, Denis C. Adler, George Jacobson, Kenneth A. Heitmann and Derrell D. Watson, Oct., 530
—transduodenal cholangiography (ab), H. Gaylis and Kenneth Gunn, Dec., 953
- cysts**
—cystic dilatation of Brunner's glands (ab), Irvin M. Becker, Aug., 302
—enterogenous cyst; case and review of literature (ab), Karl Mendl and Clive H. Tanner, Oct., 635
- diverticula**
—pathogenetic study of duodenal diverticulum in unusual location (ab), F. Gudjons, Sept., 469
- stula.** See **Fistula**
- mucosa**
—neglect of gastroduodenal mucosa by clinicians and radiologists (ab), V. J. Kinsella, Sept., 468
- tumors**
—benign and malignant tumors, Eugene Freedman, Marcus H. Rabwin and Marcella Sava, Oct., 557
—hyperplasia of Brunner's glands (ab), A. A. Epstein and L. J. Cole, Oct., 635
- DURBIN, PATRICIA W.** See **HAMILTON, JOSEPH G.**
- du TOIT, F. S.:** Tuberculo-silicosis (ab), Sept., 463
- DVORACEK, CESTIMIR.** See **KUCERA, JAN**
- DYSART, D. N.** See **SEEDORF, E. E.**
- DYSOSTOSIS, METAPHYSEAL.** See **Bones, growth**
- DYSPHAGIA**
—dysphagia and unusual radiographic appearances associated with variable relationships of aorta and lower esophagus (ab), Eric H. Mucklow and Oliver E. Smith, Aug., 296
—in carcinoma of pancreas (ab), L. Langton and J. W. Laws, Aug., 304
—of transitory type produced by hypertrophic spurs on cervical vertebrae (ab), Hugh Stephens and William L. Janus, Aug., 306
- DYSPLASIA, CHONDROECTODERMAL.** See **Ectodermal Defect**
- DYSPLASIA, DIAPHYSEAL.** See **Bones**
- DYSPLASIA, EPIPHYSEAL.** See **Epiphyses**
- DYSPLASIA, FIBROUS.** See **Face**
- DYSPLASIA, METAPHYSEAL.** See **Bones**
- E**
- EAR**
—atrophy of auricular and nasal cartilages following administration of chorionic gonadotrophins in case of arthritis mutilans with sicca syndrome (ab), Fred B. Rogers and John Lansbury, Nov., 797
—microradiographic studies of auditory ossicles (malleus and incus) and of osseous labyrinth (ab), K. Karlsson et al., Sept., 462
- EBERL, J. J.:** Roentgenologic demonstration and analysis of the diaphragm and of the esophageal foramen (ab), July, 136
- EBSTEIN'S ANOMALY.** See **Tricuspid Valve**
- ECHINOCOCCOSIS.** See **Bones**
- ECKER, ARTHUR.** See **RIEMENSCHNEIDER, PAUL A.**
- ECONOMIC CONDITIONS**
—undetected tuberculosis in various economic groups (ab), Robert J. Anderson et al., Sept., 462
- ECTODERMAL DEFECT**
—chondroectodermal dysplasia (Ellis-van Creveld disease); case, Jay M. Chaus, Aug., 213
- EDEIKEN, JACK.** See **PENDERGRASS, E. P.**
- EDITORIALS**
cancer of the breast, July, 111
invitation to Annual Meeting, Tom B. Bond, Sept., 439
medical electronics, a rapidly expanding field, Lee B. Lusted, Oct., 604
physiological point of view, Robert P. Barden, Aug., 281
roentgen examination of liver, Leo G. Rigler, Dec., 936
teaching or advertising? (character of scientific exhibits), Robert P. Barden, Nov., 785
- EDLING, N. P. G., HELANDER, C. G., and RENCK, L.:** Correlation between contrast excretion and arterial and intrapelvic pressures in urography. An experimental study in rabbits (ab), Oct., 640
- EDSMAN, GUNNAR:** Malignant tumour of the spleen diagnosed by linal arteriography (ab), Oct., 641
- EDTA (ethylenediamine tetra-acetic acid)**
—“in vivo” dissolution of metastatic calcium: an approach to atherosclerosis (use of EDTA) (ab), Norman E. Clarke et al., Dec., 957
—lead EDTA complex: a water-soluble contrast medium (ab), N. Sapeika, July, 145
—lead EDTA complex: further radiographic studies (ab), N. Sapeika, July, 145
—lead calcium EDTA (ab), N. Sapeika, July, 145
- EDUCATION**
—awards in radiological research, James Picker Foundation, Sept., 451

EDUCATION—cont.

- continuation course in radiology, University of Minnesota, Sept., 450
- graduate program in biophysics, Dec., 939
- grants-in-aid for radioisotope training, Aug., 284
- medical research fellowships, Sept., 451
- Oak Ridge Institute of Nuclear Studies: special courses, Oct., 614
- postgraduate meeting in radiology, University of Kansas, Nov., 786
- radiological physics courses, University of Chicago, Sept., 451
- residency training in radiology: an announcement, Aug., 284
- teaching or advertising? (character of scientific exhibits) (ed. Robert P. Barden, Nov., 785)

EFFUSIONS. See Abdomen; Pleura; Pleurisy

EHLERS-DANLOS SYNDROME. See Joints

EHRLICH, MARGARETE. See McLAUGHLIN, WILLIAM L.

EISEN, DAVID, SHAPIRO, ISRAEL, and FISCHER, J. B.: A case of cryptococcosis with involvement of lungs and spine (ab), Nov., 802

EISENBERG, I. J., TERNER, I. S., and LEOPOLD, I. H.: Use of P^{32} as an aid in diagnosis of intraocular neoplasms. Further observations (ab), Sept., 486

EKA-IODINE (Astatine). See Radioactivity

EKENGREN, KRISTINA: Roentgenographic diagnosis of genital tuberculosis in the female and roentgenographic effects of antibiotic therapy (ab), Nov., 820

ELBOW

—congenital ankylosis (ab), Richard Y. Card and Jerome Strachman, Nov., 817

—roentgenologic visualization of extracapsular fat: its importance in diagnosis of traumatic injuries to elbow (ab), Hans-Gösta Norell, July, 139

ELDRIDGE, FREDERIC L., HULTGREN, HERBERT N., LIU, CHI KONG, and BLUMENFELD, MARGARET: A study of the clinical reactions to venous angiocardiology (ab), Dec., 950

ELECTROCARDIOGRAPHY. See Cardiovascular System

ELECTROLYTES. See Blood, chemistry

ELECTRONS AND ELECTRONICS

See also Betatron

—electron energy distribution produced by gamma rays (ab), H. E. Johns et al, Aug., 324

—medical electronics, a rapidly expanding field (ed), Lee B. Lusted, Oct., 604

— α -radiation from electronic power tubes (ab), S. C. Ballard, Aug., 324

ELGEE, NEIL J., and WILLIAMS, ROBERT H.: Effects of thyroid function on insulin- I^{131} degradation (ab), Nov., 829

—Pituitary and adrenal influences on insulin- I^{131} degradation (ab), Nov., 829

ELKIN, MILTON. See ETTINGER, ALICE

ELLIS, FRANK, and OLIVER, R.: Treatment of papilloma of bladder with radioactive colloidal gold Au^{198} (ab), Nov., 830

ELLIS, MARIE. See COLE, LEONARD J.

ELLIS-VAN CREVELD SYNDROME. See Ectodermal Defect

ELSON, L. A.: A comparison of the effects of radiation and radiometric chemicals on the blood (ab), Nov., 832

EMANUEL, R. W.: Gargoylism with cardiovascular involvement in two brothers (ab), Aug., 295

EMBOLISM

—Pantopaque pulmonary embolism: a complication of myelography (ab), Leonard B. Ginsburg and Alan B. Skorneck, Nov., 817

EMERSON, ROGER. See GUSBERG, S. E.

EMERY, E. W.: Three years' use of a cobalt 60 unit (ab), Aug., 318

EMOTIONS

—roentgen studies of effects on small intestine from emotional disturbances (ab), Jack Friedman, July, 132

EMPHYSEMA

—mediastinal

—as complication of therapeutic pneumoperitoneum (ab), B. Mukherjee and K. R. Adhikary, Oct., 628

—pulmonary

—generalized emphysema as isolated manifestation of early cystic fibrosis of pancreas, Theodore E. Keats, Aug., 223

—regressive giant bullous emphysema in tuberculosis of adults (ab), Donato G. Alarcon, Nov., 801

—relationship of agenesis of lung to emphysema and cor pulmonale (ab), A. L. Warner et al, Dec., 946

—tension emphysema: surgical emergency in infants (ab), T. Y. Nelson and Douglas Key, Aug., 292

ENAMEL. See Teeth

ENDOMETRIUM. See Uterus, cancer

ENEMAS. See Intestine, roentgenography; Intussusception

ENGELMANN-CAMURATI DISEASE. See Bones, diseases

ENGELSTAD, O. D. See CORNATZER, W. E.

ENGSTROM, A. See KARLSSON, K.

ENGSTROM, H. See KARLSSON, K.

ENTERIC COATING. See Pills

ENTERLINE, PHILIP E. See ANDERSON, ROBERT J.

EOSINOPHILS

—radiation sickness: a study of its relation to adrenal cortical function and the absolute eosinophil count (ab), Elliott C. Lasser and K. Wilhelm Stenstrom, July, 154

—vertebra plana (Calvé's disease) due to eosinophilic granuloma (ab), Edward L. Compere et al, Aug., 307

EPICONDYLITIS. See Humerus

EPIDIDYMIS

—vaso-epididymography and vasoseminal vesiculography (ab), Benjamin S. Abeshouse et al, Sept., 481

EPIPHYSES

—metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. I. Familial metaphyseal dysplasia and craniometaphyseal dysplasia; their relation to leontiasis ossea and osteopetrosis; disorders of "bone remodeling" (ab), W. P. U. Jackson et al, Oct., 636

—metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. II. Multiple epiphyseal dysplasia; its relation to other disorders of epiphyseal development (ab), W. P. U. Jackson et al, Oct., 637

—metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. III. Progressive diaphyseal dysplasia (ab), W. P. U. Jackson et al, Oct., 637

—roentgen examination of proximal femur end in children and adolescents: a standardized technic also suitable for determination of collum-, anteversion-, and epiphyseal angles: study of slipped epiphysis and coxa plana (ab), Lars Billing, July, 140

—slipping of upper femoral epiphysis: epiphysiolysis, epiphysiolisthesis, epiphysal separation or fracture, epiphysal coxa vara (ab), Carl E. Mosse, Aug., 307

EPIPOIC APPENDAGES

—extrinsic deformities of colon mimicking carcinoma; 3 cases (2 due to adherence of an epiploic appendix, 1 due to band of fibrous adhesions encircling right colon and ileum) (ab), Robert C. Overton et al, Sept., 471

EPITHELIUM

—malignant transformation of squamous epithelium: cytochemical study with special reference to cytoplasmic nucleic acids and proteins (ab), Gunnar Moberger, July, 156

EPPELSON, DEAN P. See COMFORT, MANDRED W.

EPSTEIN, A. A., and COLE, L. J.: Hyperplasia of Brunner's glands (ab), Oct., 635

EPSTEIN, FREDERICK H. See HYMAN, JULIAN B.

EPSTEIN, JOSEPH A.: Syndrome of herniation of the lower thoracic intervertebral discs with nerve root and spinal cord compression. A presentation of four cases with a review of the literature, methods of diagnosis and treatment (ab), Sept., 477

ERDMANN, H.: Indications for x-ray examination of the intestinal tract in patients with pulmonary tuberculosis (ab), Aug., 303

ERHARD, GERALD A. See PIATT, ARNOLD D.

ERYTHROCYTES

—anemia and erythropoiesis in irradiated rat: an experimental study with particular reference to technics involving radioactive iron (ab), C. F. Baxter et al, Nov., 830

—combined effects of total-body x-irradiation and radiant energy thermal burns on osmotic and mechanical fragility of erythrocyte (ab), E. L. Alpen et al, Oct., 651

—effect of hydroxylamine and x-irradiation on red cell destruction and formation and serum iron concentration (ab), Alfred Chanutin and Elizabeth L. Word, Oct., 652

—uptake of radioactive iron (Fe^{59}) by nucleated red cells in vitro (ab), L. G. Lajtha and H. D. Suit, Nov., 830

—use of isotope Cr^{51} as label for red cells (ab), P. L. Mollison and N. Veall, Nov., 831

elliptical

—dental bone changes occurring in sickle-cell diseases and abnormal hemoglobin traits, Joseph R. Prowler and Ernest W. Smith, Nov., 702

ERYTHROPOIESIS. See Erythrocytes

ESKELSON, C. D. See BOTKIN, A. L.

ESOPHAGUS

See also Hernia, diaphragmatic

—gastroesophageal vestibule, its normal function and its role in cardiospasm and gastroesophageal reflux (ab), Franz J. Ingelfinger et al, Aug., 301

—subacute erosive ("peptic") esophagitis: clinical study of 100 cases (ab), Eddy D. Palmer, July, 128

roentgenography

—barium in hydrogen peroxide in esophageal and gastric diagnosis, Cesare Gianturco and George A. Miller, Oct., 569

—dysphagia and unusual radiographic appearances associated with variable relationships of aorta and lower esophagus (ab), Eric H. Mucklow and Oliver E. Smith, Aug., 296

—left lateral esophagram in mitral valvular disease (ab), J. M. McKay and J. D. Aitchison, Nov., 804

—relationship of left atrium to opacified esophagus in upright and recumbent positions, Charles M. Nice, Jr., and C. William Hall, July, 61

—roentgenologic demonstration and analysis of diaphragm and of esophageal foramen (ab), J. Rherl, July, 136

rupture

—spontaneous rupture (ab), Tibor Bodi et al, July, 129

—spontaneous rupture (ab), J. Roger Boule, Nov., 808

stricture

—stenosis of esophagus and stomach following ingestion of corrosive substances (ab), Byron G. McKibben and Samuel Lee, Nov., 809

ETTINGER, ALICE, and ELKIN, MILTON: Study of the sigmoid by special roentgenographic views (ab), July, 132

- EVANS, ARTHUR T.:** Renal arteriography (ab), Aug., 310
EVANS, JOHN. See **GLENN, FRANK**
EVANS, JOHN A. See **STEINBERG, ISRAEL**
EVANS, TITUS C.: Protection measures in a university, Dec., 875

—See **LEINFELDER, P. J.**

EXHIBITS

- teaching or advertising? (ed), Robert P. Barden, Nov., 785

EXOPHTHALMOS

- neurofibromatosis and congenital unilateral pulsating and non-pulsating exophthalmos (ab), André J. Bruwer and Robert R. Kierland, Nov., 797

EXPLOSIONS

See also Atomic Bomb

- fires and explosions in anesthesia, John B. Dillon, July, 108

EXTREMITIES

See also Arms; Legs

- fat of radiopaque media injected into cancellous bone of extremities (ab), R. G. Harrison and H. H. Gossman, Dec., 955
 —study of lymph drainage of lower limb with use of colloidal radiogold (Au¹⁹⁹) (ab), K. A. Hultborn et al, Dec., 964

blood supply

- angiographic observations on development of vascular disease and circulatory disturbances, with special attention to terminal vessels (ab), E. Vogler, Aug., 300
 —evaluation of method of phlebography of lower extremities (ab), D. A. Felder and T. O. Murphy, Dec., 952
 —percutaneous angiography with special reference to peripheral vessels (ab), David Sutton, Nov., 808
 —peripheral arteriosclerosis: clinical and arteriographic evaluation with reference to conservative surgical treatment (ab), H. P. Totten, Aug., 299
 —technic of ascending phlebography of lower extremity (ab), Torgny Greitz, Oct., 632
 —venous occlusion of lower extremities in paraplegic patients (ab), Ernest Bors et al, Aug., 300

EYES

See also Cataract; Cornea; Exophthalmos; Lacrimal Organs; Lens, Crystalline; Orbit

- adaptation for fluoroscopy (letter to editor), William G. Faraghan, Nov., 787
 —Geiger counter probe for diagnosis and localization of posterior intraocular tumors (ab), Charles I. Thomas et al, July, 154
 —neuromyelitis optica simulating spinal cord tumor. Case, with review of 9 additional cases (ab), James W. Markham and Frank J. Otenasek, Oct., 626
 —persistent carotid-basilar anastomosis associated with aneurysm of homolateral middle cerebral artery manifested by oculomotor palsy; case (ab), Frederick Murtagh et al, Nov., 795
 —use of P³² as aid in diagnosis of intraocular neoplasms; further observations (ab), I. J. Eisenberg et al, Sept., 486

foreign bodies

- metallic fragments of blasting caps (letter to editor), Donnan B. Harding, July, 115

EYMER, HEINRICH, and RIES, JULIUS: Results of radiation therapy of carcinoma of the cervix at the First Gynecological Clinic of the University of Munich in the years 1947 and 1948 (ab), Sept., 483

F

FACE

- cephalographic diagnosis in the surgical treatment of malformations of face (ab), Harry H. Shapiro and John M. Converse, Oct., 626
 —laminography in acute maxillofacial injuries, Richard P. McClure, Sept., 408
 —ossifying fibromas (fibrous dysplasia) of facial bones in children and adolescents (ab), Nicholas Georgiade et al, Nov., 796

FALK, S. See **SNAPPER, I.**

FALLOPIAN TUBES

- diagnosis of tubointestinal and tubovesical fistulas by hysterosalpingography (ab), Samuel Rozin, Oct., 639
 —foreign body granulomas following hysterosalpingography with contrast medium containing carboxymethylcellulose (ab), F. Bergman et al, Nov., 821
 —opacification of a calcified leiomyoma during hysterosalpingography (ab), Meyer Alpert and B. Douglas Lecher, July, 142
 —ovarian radiation during hysterosalpingography (ab), R. Barnett and D. K. Bewley, Nov., 819
 —simplified, inexpensive technic in hysterosalpingography (ab), Arthur J. Bendick, Sept., 479
 —tubal ligation (sterilization) by a modified Madlener method (ab), W. J. Dieckmann and J. P. Harrod, Jr., July, 142
 —tuberculosis
 —roentgenographic diagnosis of genital tuberculosis in female and roentgenographic effects of antibiotic therapy (ab), Kristina Ekengren, Nov., 820
 —role of hysterosalpingography in diagnosis of genital tuberculosis (ab), Olli Ylinen and C.-E. Johanson, Nov., 820

FALLOT'S TETRALOGY. See Heart, abnormalities

FAMILIAL CONDITIONS

See also Heredity

- familial metaphyseal dysplasia, Harold Feld, Robert A. Switzer, Morris W. Dexter and Edward M. Langer, Aug., 206
 —familial osteochondritis dissecans (ab), M. Pickering Pick, Dec., 954
 —metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. I. Familial metaphyseal dysplasia and craniometaphyseal dysplasia; their relation to leontiasis ossea and osteopetrosis; disorders of "bone remodeling" (ab), W. P. U. Jackson et al, Oct., 636
 —osteochondritis dissecans in three members of one family (ab), T. B. Gardiner, Dec., 954

FANGER, HERBERT. See **BÓDI, TIBOR**

FARR, R. F.: The specification of roentgen ray output and quality (ab), Dec., 958

FAT

- fat absorption test using iodized oil, with particular application as a screening test in diagnosis of fibrocystic disease of pancreas (ab), Frederic N. Silverman and Harry C. Shirkey, Dec., 954
 —roentgenologic characteristics of epicardial fat pad with case report, Joseph R. Nahon, Nov., 745
 —roentgenologic visualization of extracapsular fat: its importance in diagnosis of traumatic injuries to elbow (ab), Hans-Gösta Norell, July, 139

FEDER, I. See **SNAPPER, I.**

FEHER, GEORGE S. See **DENENHOLZ, EDWARD J.**

FEISSLY, R. See **JALLUT, O.**
FELD, HAROLD, SWITZER, ROBERT A., DEXTER, MORRIS W., and LANGER, EDWARD M.: Familial metaphyseal dysplasia, Aug., 206

FELDER, D. A., and MURPHY, T. O.: Evaluation of a method of phlebography of the lower extremities (ab), Dec., 952

FELLOWSHIPS. See Education

FELSON, BENJAMIN: Translumbar arteriography in intrinsic disease of the abdominal aorta and its branches (ab), Aug., 296

FEMUR

- roentgen examination of proximal femur end in children and adolescents: a standardized technic also suitable for determination of the collum-, anteversion-, and epiphyseal angles: a study of slipped epiphysis and coxa plana (ab), Lars Billing, July, 140
 —slipping of upper femoral epiphysis: epiphysiolysis, epiphysiolisthesis, epiphysal separation or fracture, epiphysal coxa vara (ab), Carl E. Mosse, Aug., 307

FERGUSON, CHARLES. See **DICK, D. R.**

FERGUSON, CHARLES F., and FLAKE, CARLYLE G.: Tracheographic and bronchographic studies as aids in the diagnosis of congenital malformations of the tracheo-bronchial tree and aortic arch in infants and children (ab), Oct., 628

FERGUSON, J. D.: Irradiation therapy for prostatic cancer (ab), Oct., 645

FERLAZZO, G., NICHOLSON, T., JACOBSON, A., and BUSHMAN, M.: Radiation hazard evaluation and control in hospitals, Dec., 892

FERNSTRÖM, I. See **BORELL, U.**

FESSAS, PHAEDON. See **WINTROBE, M. M.**

FETUS

—gas in fetal circulation—a sign of fetal death; case (ab), Edwin A. Riemenschneider, Dec., 956

FEVER

- breast carcinoma: influence of a febrile illness on arrested case (ab), Gwen Hilton, Aug., 315

FIBROMA. See Tumors, fibroma

FIEBELKORN, H. J.: Concerning the radiolucency lines (so-called vacuum phenomenon) in the lumbar intervertebral disks (ab), Sept., 477

FIGIEL, LEO S., and FIGIEL, STEVEN J.: Detorsion of volvulus of the right colon. Roentgenographic considerations (ab), July, 133

Perforation of necrotizing primary retroperitoneal tumors into the gastrointestinal tract, Aug., 227

FIGIEL, STEVEN J. See **FIGIEL, LEO S.**

FILM BADGES

- film badge dosimetry: how much fading occurs? (ab), Wm. L. McLaughlin and Margaret Ehrlich, Aug., 321

FINDY, NATHANIEL, and STEINBERG, ISRAEL: Roentgen aspects of pleural mesothelioma, Aug., 169

FINERMAN, W. B.: Perforations of respiratory and alimentary tracts by metallic foreign bodies (ab), Dec., 933

FINGERS AND TOES

- avascular necrosis of phalanges of hands (Thiemann's disease) (ab), Ernest W. Shaw, Aug., 307
 —marble bone disease with brachydactylia (ab), L. Takáts and N. Henye, Nov., 818
 —range of movement of great toe in men (ab), J. Joseph, Aug., 308
 —traumatic Heberden's nodes: osteoarthritis of fingers due to injury (ab), Robert M. Stecher and Harry Hauser, July, 140
 —undigital clubbing; case (ab), Basil A. Stoll and W. R. Beetham, Sept., 479
 —unilateral clubbing of fingers due to absence of aortic arch (ab), E. R. Dorney et al, Nov., 800

- FINKE, H.:** Differentiation of benign bronchostenosis and its relation to atelectasis (ab), Dec., 947
- FINLAY, J. M., and MACDONALD, R. IAN:** Acromegaly (ab), Sept., 473
- FIRES**
—fires and explosions in anesthesia. John B. Dillon, July, 108
- FIRSHEIM, H. E.** See **BOTKIN, A. L.**
- FISCHER, J. B.** See **EISEN, DAVID**
- FISTULA**
See also Arteries, pulmonary
- arteriovenous**
—congenital subclavian arteriovenous fistula and a truncus brachiocephalicus totalis in same patient (ab), O. Peräsalo and K. E. J. Kyllönen, Aug., 297
- hereditary hemorrhagic telangiectasia: report of pulmonary arteriovenous fistulae in mother and son: medical (hormonal) and surgical therapy of this disease (ab), Edward C. Heyde, Sept., 466
- pulmonary arteriovenous fistula and telangiectasia (ab), Eugene Weiss and Benjamin M. Gasul, Sept., 465
- duodenocolic**
—malignant duodenal colic fistula; case (ab), Bruce T. Colwell, July, 132
- duodenorenal**
—complication of peptic ulceration (ab), Francis E. Stock, Sept., 470
- sigmoidouterine**
—complicating diverticulitis; case (ab), M. Harlan Johnston and George M. Stubbs, Nov., 811
- tubointestinal**
—diagnosis of tubointestinal and tubovesical fistulas by hysterosalpingography (ab), Samuel Rozin, Oct., 639
- tubovesical**
—diagnosis of tubointestinal and tubovesical fistulas by hysterosalpingography (ab), Samuel Rozin, Oct., 639
- FIUMICELLI, ALIGI.** See **CECCHI, ELVIO**
- FLAKE, CARLYLE G.** See **FERGUSON, CHARLES F.**
- FLATFOOT.** See **Foot**
- PLATULENCE**
—gastrointestinal distention in infants (ab), Alex Gerber, Nov., 809
- FLEISCHNER, FELIX G., and SAGALL, ELLIOT L.:** Pulmonary arterial oligemia in mitral stenosis as revealed on the plain roentgenogram, Dec., 857
- FLETCHER, C. M.:** Classification of roentgenograms in pneumoconiosis (ab), Nov., 800
- FLETCHER, DENIS E.:** Skeletal involvement in carcinoma of the urinary bladder (ab), Aug., 308
- FLIEDNER, M. TH.** See **STODTMEISTER, R.**
- FLORENCE, THOMAS J.** See **WEENS, H. STEPHEN**
- FLORES COVARRUBIAS, TEODORO:** Orthostereoradiography in obstetrics. Precision method for cephalopelvimetry (ab), Aug., 309
- FLUOROSCOPY.** See **Roentgen Rays, fluoroscopy**
- FLYNN, J. E., SIEBENS, A. A., and WILLIAMS, S. F.:** Congenital absence of a main branch of the pulmonary artery (ab), Oct., 630
- FOOT**
—bone anomalies of tarsus in relation to "peroneal spastic flatfoot" (ab), E. A. Jack, Sept., 479
- rigid valgus foot due to talocalcaneal bridge (ab), R. I. Harris, Nov., 819
- FORAKER, ALVAN G., DENHAM, SAM W., and MITCHELL, DOROTHY D.:** Histochemical studies of the effect of irradiation of the placenta (ab), Nov., 832
- FORAMEN**
Luschka's. See **Brain, abnormalities**
Magendie's. See **Brain, abnormalities**
mental. See **Jaws**
- FORD, LEE T., and KEY, J. ALBERT:** Experimental study of effect of pressure on healing of bone (ab), Sept., 475
- FORD, WILLIAM B.** See **KENT, EDWARD M.**
- FOREIGN BODIES**
See also Eyes; Kidneys
—foreign body granulomas following hysterosalpingography with contrast medium containing carboxymethylcellulose (ab), F. Bergman et al, Nov., 821
- opaque vaginal suppository mistaken for bladder calculus (letter to editor), George E. Irwin, Jr., Nov., 788
- perforations of respiratory and alimentary tracts by metallic foreign bodies (ab), W. B. Finerman, Dec., 953
- x-ray delineation of ingested enteric-coated substances (ab), Percy Barsky, Dec., 952
- FORNI, G.** See **LURÄ, A.**
- FORREST, S. J., and GOLDBERG, L.:** Pheochromocytoma. A case report (ab), July, 145
- FORSEE, JAMES H.** See **GOYETTE, EDWIN M.**
- FORSBERG, A.** See **HULTBORN, K. A.**
- FORSBERG, ARNE G., and HEVESY, GEORGE:** Effect of x-rays and hormones on resorption rate of injected NaHCO_3 (ab), Dec., 968
- FORSYTHE, THOMAS.** See **BÓDI, TIBOR**
- FOSSA**
posterior. See **Cranium, cysts**
- FOULKES, JOHN F., and FRASER, RUSSELL:** Radioiodine tests in a case of struma ovarii (ab), Aug., 317
- FOWLER, N. O.** See **DORNEY, E. R.**
- FRACTURES**
—Sudeck's syndrome after fractures (ab), G. Bierling and D. Reich, Nov., 815
- Milkman's.** See **Ribs**
- FRAENKEL, M.** See **SCHORR, S.**
- FRAJOLA, WALTER J.** See **ACKERMAN, G. ADOLPH**
- FRANCIS, KENNETH C., PHILLIPS, RALPH, NICKSON, JAMES J., WOODARD, HELEN O., HIGINBOTHAM, NORMAN L., and COLEY, BRADLEY L.:** Massive preoperative irradiation in the treatment of osteogenic sarcoma in children. A preliminary report (ab), Sept., 482
- FRANÇOIS, J., and DE WITTE, FR.:** Roentgen findings and intracerebral calcifications in congenital toxoplasmosis (ab), Nov., 796
- FRASER, J. E. E., and BARNETT, A. J.:** Thoracic outlet syndrome: case associated with short "first" rib, aneurysm of the subclavian artery and occlusion of brachial artery (ab), Sept., 476
- FRASER, RUSSELL.** See **FOULKES, JOHN F.**
- FRECKER, E. W.:** Radiotherapy in bladder carcinoma (ab), Dec., 961
- FREEDBERG, A. STONE.** See **BLUMGART, HERRMAN L.**
- FREEDMAN, EUGENE, RADWIN, MARCUS, and SAVA, MARCELLA:** Benign and malignant tumors of the duodenum, Oct., 557
- FREEMAN, BETTY B.** See **DAVIDSON, JACK D.**
- FRENCH, LYLE A., and PEYTON, WILLIAM T.:** Vascular malformations in the region of the great vein of Galen (ab), July, 126
- FRIEDEL, HYMER L.** See **STORAASLI, JOHN P.**
- FRIEDMAN, JACK:** Roentgen studies of the effects on the small intestine from emotional disturbances (ab), July, 132
- and **GOLDNER, MEYER Z.:** Discography in evaluation of lumbar disk lesions, Nov., 653
- FRIEDMAN, LOUIS L.:** Significant case of pneumoconiosis in a soft-coal worker (ab), Dec., 948
- FRIEDMAN, NATHAN B.:** Pathogenesis of intestinal ulcers following irradiation. Effects of colostomy and adhesions (ab), Nov., 831
- FRIMANN-DAHL, J.:** Administration of barium orally in acute obstruction: advantages and risks (ab), Aug., 302
- FROMAN, ABEL:** The value of the routine chest x-ray film in detecting diaphragmatic hernia. A report of 53 cases (ab), Aug., 306
- FUCHS, G.:** A new method for field localization in x-ray therapy (ab), Aug., 316
- FULTON, GEORGE P., and SUDAK, FREDERICK N.:** Effect of total body x-irradiation on serum electrolyte levels and electrocardiograms of the golden hamster (ab), Aug., 322
- FURNO, EDWARD J.** See **TROUT, E. DALE**
- FURTH, JACOB, DENT, JAMES N., BURNETT, WILLIAM T. Jr., and GADSDEN, EVELYN L.:** Mechanism of induction and the characteristics of pituitary tumors induced by thyroidectomy (ab), Nov., 828
- See **UPTON, A. C.**
- FUSI, GIORGIO.** See **CIARPAGLINI, LUIGI**
- G**
- GABRYSH, A. F., and DAVIS, F. J.:** Radon released from concrete in radium heating (ab), Nov., 835
- GADSDEN, EVELYN L.** See **FURTH, JACOB**
- GAEBEL, E., and TESCHENDORF, W.:** Progress in roentgenologic demonstration of gallbladder (ab), July, 134
- GAGE, ROBERT P.** See **COMFORT, MANDREW W.**
- GAGNON, JACQUES.** See **CHAPMAN, WILLIAM P.**
- GALE, GODFREY L.:** Some serious complications of tuberculous lymph nodes: fatal hemoptysis, false aneurysm, occluded cisterna chyli and obstructive jaundice. A review with a report of five cases (ab), Sept., 462
- GALEN'S VEIN.** See **Veins, cerebral**
- GALLBLADDER**
diseases
—place of intravenous cholecystogram in diagnosis of acute cholecystitis (ab), Rudolph M. Gonzalez et al, Aug., 304
- roentgen diagnosis of gallbladder and biliary tract disease without cholecystography (ab), Robert L. Scanlan and Barton R. Young, Aug., 304
- diverticula
—cholecystitis glandularis proliferans (diverticula of gallbladder) (ab), L. Ian Burt and H. Masel, Dec., 953
- roentgenography
—accuracy of x-ray examination (ab), Howard Mauthe, July, 134
- clinical and roentgenologic evaluation of routine 2-gram Telepaque dosage in cholecystography, Walter M. Whitehouse and O. Martin, Sept., 422
- comparative clinical study of Teridax (3 gm.) and Telepaque (2 gm.) in routine cholecystography, Walter M. Whitehouse, Sept., 425
- comparison of 5 gallbladder media (ab), E. E. Seedorf et al, Aug., 304
- correlation of surgical pathology with Telepaque cholecystography in doses of two grams (ab), Walter M. Whitehouse, Dec., 953
- gallbladder function (cholecystographic studies) following non-specific trauma: systemic response to trauma (ab), John M. Howard, Oct., 636
- intravenous cholecystography and cholangiography: clinical trials with a new medium (Biligradin) (ab), David Sutton and John V. Tillett, Aug., 306
- 117 cases examined by intravenous cholecystocholangiography (ab), A. Maléki, Sept., 472

- GALLBLADDER, roentgenography**—*cont.*
—progress in roentgenologic demonstration (ab), E. Gaebel and W. Teschendorf, July, 134
—visualization of biliary tract by means of Biligrafin, especially after cholecystectomy (ab), Werner Teschendorf, Aug., 305
- GAMBLE, DEAN.** See **MOORE, VINCENT**
- GAMMA RAYS.** See Atomic Bomb; Electrons and Electronics; Radioactivity; Radium
- GARCIA, ALEXANDER.** See **CARROLL, ROBERT E.**
- GARCIA, MANUEL.** Further observations on tissue dosage in cancer of the cervix uteri (ab), Nov., 824
- GARDINER, T. B.** Osteochondritis dissecans in three members of one family (ab), Dec., 954
- GARGOLISM.** See Lipocholesterolodystrophy
- GARLAND, L. H.** Chest surveys: A symposium. Introduction, July, 19
Rationale and results of simple mastectomy plus radiotherapy in primary cancer of the breast (ab), Oct., 643
- GARRITY, RICHARD W., and MATTHEWS, LEROY W.** Radioactive phosphorus in management of brain tumors (ab), Oct., 648
- GARY, JOHN E., and SCHATZKI, RICHARD.** Radiologic examination of the gastrointestinal tract (ab), Oct., 633
- GAS**
—gas in fetal circulation—a sign of fetal death: case (ab), Edwin A. Riemschneider, Dec., 936
- GASPARINI, S., and MENEGHINI, C.** Ascariasis of the biliary tract: radiologic demonstration by barium reflux (ab), July, 134
- GASTROINTESTINAL TRACT**
See also Colon; Intestines; Stomach; etc.
—dilatation
—distention in infants (ab), Alex Gerber, Nov., 809
—diverticula
—further report on combination of diverticula in gastrointestinal tract with hiatal hernia (ab), J. Smulewicz, July, 130
—motility
—in man: influence of standard meal on effect of Banthine (ab), William P. Chapman et al, Oct., 634
—mucosa
—radiolucent pneumatic compressor for mucosal studies, Isadore Katz, Aug., 271
—perforation
—perforation of necrotizing primary retroperitoneal tumors into gastrointestinal tract, Leo S. Figiel and Steven J. Figiel, Aug., 227
—perforations of respiratory and alimentary tracts by metallic foreign bodies (ab), W. B. Finerman, Dec., 953
roentgenography
—ascariasis of biliary tract: radiologic demonstration by barium reflux (ab), S. Gasparini and C. Meneghini, July, 134
—of upper gastrointestinal tract (ab), J. E. Miller, Sept., 467
—radiologic examination (ab), John E. Gary and Richard Schatzki, Oct., 633
—tumors
—Kaposi's disease; unusual case, James H. Grove, Aug., 236
—manifestations of Hodgkin's disease of gastrointestinal tract (ab), U. V. Portmann et al, Sept., 468
- GASJAN, BENJAMIN M.** See **WEISS, EUGENE**
- GAY, BRIT B., Jr.** See **RAYLE, ALBERT A., Jr.**
- GAYLIS, H., and GUNN, KENNETH.** Transduodenal cholangiography (ab), Dec., 953
- GEDDA, PER O., and LINDGREN, MARTIN.** Pituitary and orbital roentgen therapy in the hyperophthalmopathic type of Graves' disease (ab), July, 148
- GEIGER-MÜLLER COUNTER.** See Counters
- GELLIN, GERALD A.** See **GLASS, GEORGE B. JERZY**
- GELORMINI, O. J.** See **BACHMAN, C. H.**
- GENITOURINARY TRACT.** See Urinary Tract; under names of organs
- GENNA, S., and LAUGHLIN, J. S.** Absolute calibration of a cobalt-60 gamma-ray beam, Sept., 394
- GEORGE, ROBERT S.** See **KENT, EDWARD M.**
- GEORGIADIS, NICHOLAS, MASTERS, FRANK, HORTON, CHARLES, and PICKRELL, KENNETH.** Ossifying fibromas (fibrous dysplasia) of the facial bones in children and adolescents (ab), Nov., 796
- GERBASI, FRANCIS S.** Pericardial conelomic cyst simulating chronic pericardial effusion: report of a case (ab), Aug., 294
- GERBER, ALEX.** Gastrointestinal distention in infants (ab), Nov., 809
- GERIATRICS.** See Old Age
- GERNEZ-RIEUX, CH., and LEPAUL, G.** Meningoceles of intrathoracic development (ab), July, 127
- GERSHON-COHEN, JACOB, INGLEY, HELEN, and HERMEL, MORTIMER E.** Neglected roentgenography of breast disease (ab), Nov., 819
- SCHRAER, HARALD, and BLUMBERG, NATHAN.** Bone density measurements of osteoporosis in the aged, Sept., 416
—See **COHN, EDWIN M.**
- GERSTNER, HERBERT B., ORTH, JOHN S., and RICHEY, EVERETT O.** Effect of high-intensity x-radiation on velocity of nerve conduction (ab), Nov., 832
- GHEN, K. M.** See **YANG, SZE-PIAO**
- GIANTURCO, CESARE, and MILLER, GEORGE A.** Barium in hydrogen peroxide in esophageal and gastric diagnosis, Oct., 569
Bilateral bronchography. New material and technic, July, 57
- GIBSON, R. V.** See **ARTHURTON, M. W.**
- GILLETTE, LEE.** See **TWISS, J. RUSSELL**
- GIMES, BELA, and SZENDROI, ZOLTÁN.** The significance of serum protein shifts in the diagnosis of bone tumors (ab), Sept., 475
- GINSBURG, LEONARD B., and SKORNECK, ALAN B.** Pantopaque pulmonary embolism. A complication of myelography (ab), Nov., 817
- GIUS, JOHN A., TIDRICK, ROBERT T., and HICKEY, ROBERT C.** Extension of immediate cholangiography in common duct surgery (ab), July, 135
- GLASS, GEORGE B. JERZY, BOYD, LYNN J., and GELLIN, GERALD A.** Surface scintillation measurements in humans of the uptake of parenterally administered radioactive vitamin B₁₂ (ab), Dec., 966
- GLAZER, NORMAN M.** See **HAUSER, HARRY**
- See **RACK, FRANK J.**
- GLEASON, G. I.** See **LAHR, T. N.**
- GLENDINING, A. C.** Occasional bronchography (ab), Nov., 798
- GLENN, FRANK, EVANS, JOHN, HILL, MALCOLM, and MCLENAHAN, JOHN.** Intravenous cholangiography (ab), Aug., 305
- GLOMERULONEPHRITIS.** See Nephritis
- GLOMUS JUGULARE.** See Jugular Body
- GLOVER, ROBERT P., O'NEILL, THOMAS J. E., GONTIGO, HUGO, MAULIFFER, THOMAS C., and WELLS, C. R. E.** The surgery of infundibular pulmonic stenosis with intact ventricular septum (a type of "pure" pulmonic stenosis) (ab), Sept., 465
- GLUCKMAN, JONATHAN.** See **SAMUEL, ERIC**
- GODWIN, JOHN T.** See **SHELLABARGER, C. J.**
- GOETSCH, E.** Roentgenologic findings in diffuse scleroderma (ab), Dec., 957
- GOITER.** See Goiter. Exophthalmic; Thyroid
- GOITER, EXOPHTHALMIC**
—pituitary and orbital roentgen therapy in hyperophthalmopathic type of Graves' disease (ab), Per Olof Gedda and Martin Lindgren, July, 148
- GOKAY, HUSAMEDDIN, and BUCY, PAUL C.** Osteochondroma of the lumbar spine. Report of a case (ab), Nov., 816
- GOLD, RADIOACTIVE.** See **RADIOACTIVITY**
- GOLDBERG, L.** See **FORREST, S. J.**
- GOLDEN, ROSS, honored, July, 115**
- GOLDEN, ROSS.** Amyloidosis of the small intestine (ab), July, 132
—See **MADELL, SAMUEL H.**
- GOLDENBERG, IRA S.** Intussusception (ab), Aug., 302
- GOLDNER, MEYER Z.** See **FRIEDMAN, JACK**
- GONADOTROPINS**
—atrophy of auricular and nasal cartilages following administration of chorionic gonadotropins in case of arthritis mutilans with sicca syndrome (ab), Fred B. Rogers and John Lansbury, Nov., 797
- GONDOS, BELA.** Foreign body in the left kidney and ureter (ab), Nov., 821
- GONSHERY, LEON.** See **SMITH, WILLIE W.**
- GONTIGO, HUGO.** See **GLOVER, ROBERT, P.**
- GONZALEZ, RUDOLPH M., McGRADE, EUGENE F., and CANNON, JACK A.** The place of the intravenous cholecystogram in the diagnosis of acute cholecystitis (ab), Aug., 304
- GOODMAN, PAUL H.** See **CLAYTON, R. S.**
- GOODWIN, WILLARD E.** See **MOORE, VINCENT**
- GORDON, GLENN.** See **WEINGARTEN, WILLIAM**
- GORHAM, L. W., WRIGHT, A. W., SCHULTZ, H. H., and MAXON, F. C., Jr.** Disappearing bones: a rare form of massive osteolysis. Report of two cases, one with autopsy findings (ab), Sept., 474
- GORTON, G.** See **BERGMAN, F.**
- GOSSMAN, H. H.** See **HARRISON, R. G.**
- GOTTLIEB, CHARLES, LEFFERTS, DAVID, and BERANBAUM, SAMUEL L.** Gastric volvulus. Part I (ab), Aug., 301
—See **BERANBAUM, SAMUEL L.**
- See **LEFFERTS, DAVID**
- GOUGH, J.** Correlation of radiological and pathological changes in some diseases of the lung (ab), Nov., 798
- GOULARD, ALEXANDER, Jr., and HAMPTON, AUBREY O.** Correlation of the clinical, pathological and roentgenological findings in diverticulitis (ab), July, 133
- GOULD, DAVID M., and WILLSON, JAMES K. V.** Abdominal aortography (ab), Sept., 466
- GOW, W. S.** See **WILLIS, G. C.**
- GOYETTE, EDWIN M., BLAKE, HU A., FORSEE, JAMES H., and SWAN, HENRY.** Traumatic aortic aneurysms (ab), Oct., 630
- GRAHAM, JOHN B., and GRAHAM, RUTH M.** Curability of regional lymph node metastases in cancer of the uterine cervix (ab), Dec., 959
- GRAHAM, RUTH M.** See **GRAHAM, JOHN B.**
- GRAIN DUST PNEUMOCONIOSIS.** See Pneumoconiosis
- GRAINGER, R.** See **BAIRD, I. McLEAN**
- GRANULOCYTES.** See Leukocytes

GRANULOMA

See also Spine

—foreign body granulomas following hysterosalpingography with contrast medium containing carboxymethyl cellulose (ab), F. Bergman et al., Nov., 821

GRAVES, F. T.: The anatomy of the intrarenal arteries and its application to segmental resection of the kidney (ab), July, 143**GRAVES' DISEASE.** See Goiter, Exophthalmic**GRAY, HOWARD K.** See **COMFORT, MANDRED W.****GREER, MONTE A., and SMITH, G. EDWARD:** Method for increasing the accuracy of the radiiodine uptake as a test for thyroid function by the use of desiccated thyroid (ab), Sept., 485**GREITZ, TORGNY:** The technique of ascending phlebography of the lower extremity (ab), Oct., 632**GRID THERAPY.** See Cancer, radiotherapy**GRIFFITHS, J. D.** See **CAVE, A. J. E.****GRIGGS, ROBERT C.** See **WEISBERGER, AUSTIN S.****GROSS, RUTH T.** See **KRISS, JOSEPH P.****GROVE, JAMES H.:** Kaposi's disease. Report of an unusual case, Aug., 236**GRUNOW, OTTO H.:** Radiating spicules, a non-specific sign of bone disease, Aug., 200**GUDBJERG, CARL E.:** Bronchiectasis—dextrocardia—sinusitis: a contribution to the aetiology of bronchiectasis (ab), Oct., 628

Bronchography. Technique and choice of contrast media (ab), Sept., 462

—and **THOMSEN, GREGERS:** Inflammatory changes in the bronchial glands in chronic bronchitis, demonstrated bronchographically (ab), Aug., 293**GUDE, W. D.** See **UPTON, A. C.****GUDJONS, F.:** Pathogenetic study of a duodenal diverticulum in an unusual location (ab), Sept., 469**GUNN, KENNETH.** See **GAYLIS, H.****GURDJIAN, E. S.** See **LOFTSTROM, J. E.**—See **MARTIN, F. A.****GUSBERG, S. B., TOVELL, H. M. M., EMERSON, ROGER, and ALLINA, HANNAH:** Radiosensitivity testing of cervical cancer. A preliminary report (ab), Oct., 643**GUSTAFSON, P. F., and MARINELLI, L. D.:** Spectrometric method for the study of radon partition in radium-burdened animals, July, 90**GUTNER, LEONARD B.** See **VOGL, ALFRED****GUTTADAURO, MARIO.** See **DI GUGLIELMO, LUCIO****GYLLENSWÄRD, ÅKE, and LODIN, HERMAN:** Value of selective angiocardiology in the diagnosis of complete transposition of the great vessels (ab), July, 127**GYNECOLOGY**

—deep x-ray therapy (ab), E. J. B. Hardcastle, Nov., 823

H**HAAS, LEWIS L.:** The size of the sella turcica by age and sex (ab), Sept., 460**HAAS, R. L., LATOURETTE, H. B., and WHITEHOUSE, W. M.:** Clinical applications of obstetric radiology (ab), Aug., 308**HAHN, GEORGE A.:** Carcinoma of the cervix uteri treated at the American Oncologic Hospital, 1929-1949 (ab), Nov., 824**HAHN, P. F.** See **McCLURE, C. C., Jr.****HALE, JOHN.** See **LEWIS, GEORGE C., Jr.****HALE, WILLIAM H., and STONER, RICHARD D.:** Effects of ionizing radiation on immunity (ab), Aug., 321**HALEY, THOMAS J., McCULLOH, EVE P., McCORMICK, W. G., TRUM, BERNARD F., and RUST, JOHN H.:** Response of the burro to 100 r fractional whole body gamma ray irradiation (ab), Dec., 968—See **DETRICK, LAWRENCE E.****HALL, C. WILLIAM.** See **NICE, CHARLES M., Jr.****HAMILTON, JOSEPH G., DURBIN, PATRICIA W., and PARROTT, MARSHALL:** The accumulation and destructive action of astatine²¹¹ (EKA-iodine) in the thyroid gland of rats and monkeys (ab), Aug., 320**HAMMER, F.:** Production of a transverse tomogram and failures in positioning (ab), Aug., 313**HAMMOND, CAROLYN W.:** The treatment of post-irradiation infection (ab), Aug., 321**HAMPTON, AUBREY O. (obit.),** Dec., 940**HAMPTON, AUBREY O.** See **GOULARD, ALEXANDER, Jr.****HANBURY, E. M., Jr., HESLIN, J., STANG, L. G., Jr., TUCKER, W. D., and RALL, J. E.:** Diagnostic use of ¹¹³In (ab), Oct., 647**HAND**

See also Fingers and Toes

—acute calcium deposits (ab), Robert E. Carroll et al., Nov., 817

—arterial vascularization of soft tissues of hand (ab), Herbert Conway and Richard B. Stark, Oct., 632

HANELIN, JOSEPH. See **JACKSON, W. P. U.****HANSEN, ELLIP C.** See **TWISS, J. RUSSELL****HAPPEY, R.** See **MAYLOR, A.****HARDCASTLE, E. J. B.:** Deep x-ray therapy in gynaecology (ab), Nov., 823**HARGAN, LILA A.** See **HUANG, KEE-CHANG****HARLEY, ROBINSON D.** See **MURTAGH, FREDERICK****HARRIS, JAMES A.** See **DETAR, JOHN H.****HARRIS, R. I.:** Rigid valgus foot due to talocalcaneal bridge (ab), Nov., 819**HARRIS, SAUL J.** See **TABERSHAW, IRVING R.****HARRIS, SUSANNA.** See **HARRIS, T. N.****HARRIS, T. N., HARRIS, SUSANNA, BEALE, HENRY D., and SMITH, J. J.:** Studies on the transfer of lymph node cells. IV. Effects of x-irradiation of recipient rabbits on the appearance of antibody after cell transfer (ab), Aug., 323**HARRISON, R. G., and GOSSMAN, H. H.:** The fate of radiopaque media injected into the cancellous bone of the extremities (ab), Dec., 955**HARRISS, EILEEN B.** See **BAXTER, C. F.****HARROD, J. P., Jr.** See **DIECKMANN, W. J.****HARROW, BENEDICT R.:** Intravenous urography using mixtures of radiopaque agents, Aug., 265**HAUBRICH, R., and VERSEN, E.:** Miliary pulmonary hemosiderosis in the roentgenogram (ab), July, 126**HAUSER, HARRY, and GLAZER, NORMAN M.:** Coexistent tuberculosis and carcinoma of the lung, Nov., 680—See **STECHE, ROBERT M.****HAUT, ARTHUR.** See **WINTROBE, M. M.****HAVENER, WILLIAM H., and KNORPP, CHARLES T.:** Differential radiophosphorus uptake of lens (ab), Oct., 648**HAWKES, JOHN B.** See **NAHON, JOSEPH R.****HAZARD, J. B.** See **PORTMANN, U. V.****HEAD.** See Brain; Cranium**HEADACHE**

—as first and only sign of basilar impression (ab), William R. Chambers, Nov., 796

—subluxation and deformation of cervical apophyseal joints: a contribution to etiology of headache (ab), Ákos Kovács, Nov., 816

—x-ray demonstrable lesions in occipital headache (ab), William R. Chambers, Aug., 291

HEADLEY, NORMAN C. See **ZAIMAN, HERMAN****HEART**

See also Cardiovascular System; Ductus Arteriosus; Pericardium

—in acute glomerulonephritis (ab), Timothy R. Murphy and Francis D. Murphy, July, 128

—radioactive iodine therapy in euthyroid cardiac patients with previous mitral commissurotomy (ab), Frederick W. Pobers and Henry L. Jaffe, Dec., 962

—surgical correction of eventration of diaphragm in patient with arthrogryposis: observations on cardiac manifestations of traction on diaphragm (ab), Philip Crastopol et al., Nov., 813

abnormalities

—atrial septal defects in children: clinical study with special emphasis on indications for operative repair (ab), J. Leonard Braudo et al., Oct., 629

—diagnosis of cardiac shunts by intravenous angiocardiology (ab), John Lind et al., Aug., 296

—pulmonary valvular stenosis with intact ventricular septum: isolated valvular stenosis and valvular stenosis associated with interatrial shunt (ab), Sidney S. Sobin et al., Aug., 298

—radiologic aspects of operable heart disease. I. Observations on the preoperative approach to congenital anomalies, Herbert L. Abrams, July, 31

—surgery of infundibular pulmonic stenosis with intact ventricular septum (a type of "pure" pulmonic stenosis) (ab), Robert P. Glover et al., Sept., 465

—tetralogy of Fallot with left ventricular hypertrophy (ab), Raphael N. Paul et al., Oct., 629

—ventricular septal defect, with note on acyanotic Fallot's tetralogy (ab), Paul Wood et al., Aug., 294

blood supply

—anomalous pulmonary vein drainage into coronary sinus (ab), M. W. Arthurton et al., Aug., 298

calcification

—aortic sinus aneurysm; production of intracardiac calcification and pulmonary artery fistula (ab), Joseph C. Shipp et al., Nov., 805

dilatation

—relationship of agenesis of lung to emphysema and cor pulmonale (ab), A. L. Warner et al., Dec., 946

diseases

—roentgen appearance of pulmonary veins in heart disease, Howard L. Steinbach, Theodore R. Keats and Glenn K. Sheline, Aug., 157

displacements

—bronchiectasis—dextrocardia—sinusitis: contribution to the etiology of bronchiectasis (ab), Carl E. Gudbjerg, Oct., 628

hypertrophy. See Heart, abnormalities**insufficiency**—studies on excretion of chloride by man with and without congestive heart failure, using long-life radiochloride, ³⁶Cl (ab), C. T. Ray et al., Sept., 486

—treatment of incapacitated euthyroid cardiac patients with radioactive iodine: summary of results in 1,070 patients with angina pectoris or congestive failure (ab), Herman L. Blumgart et al., Nov., 827

roentgenography. See also other subheads under Heart

—cardioangiography (direct cardiac injection of contrast medium), H. A. Clegg, P. W. Smith, C. W. Wilson and J. W. Bull, Sept., 368

—cardioangiography (direct cardiac injection of contrast medium) (ab), Philip W. Smith et al., July, 127

—interpretation of low (cardiac) arches of cardiovascular roentgen silhouette in oblique views (ab), Jorge Meneses Hoyos and José Araujo, Aug., 295

HEART, roentgenography—cont.

- relationship of left atrium to opacified esophagus in upright and recumbent positions, Charles M. Nice, Jr., and C. William Hall, July, 61
- valves. See Mitral Valve; Pulmonary Valve; Tricuspid Valve
- volume
 - determination on microfilms (ab), Gunnar Lindgren and Sven Odén, Sept., 465

HEATING

- radon released from concrete in radiant heating (ab), A. P. Gabrysh and F. J. Davis, Nov., 835

HEBERDEN'S NODES. See Fingers and Toes**HEBERT, C. L.** See DICK, D. R.

- HEIDENBLUT, A.:** Contribution to the roentgen diagnosis of primary diaphyseal tuberculosis of the long tubular bones (ab), Nov., 818

HEILBRUN, NORMAN, and BERNSTEIN, CHARLES: Roentgen abnormalities of the large and small intestine associated with prolonged cathartic ingestion, Oct., 549**HEITMANN, KENNETH A.** See ADLER, DENIS C.**HEITZMAN, E. ROBERT.** See RIGLER, LEO G.**HELANDER, C. G.** See EDLING, N. P. G.**HELLER, EUGENE.** See ABESHOUSE, BENJAMIN S.**HEMANGIOBLASTOMA.** See Tumors, angioma**HEMANGIOMA.** See Tumors, angioma**HEMATOMA**

- angiography in evaluation of intracranial trauma (intracranial hematoma), J. E. Lofstrom, J. E. Webster and E. S. Gurdjian, Dec., 847
- of rectus sheath (ab), Geoffrey Mizbah, Oct., 639

HEMOGLOBIN

- dental bone changes occurring in sickle-cell diseases and abnormal hemoglobin traits, Joseph R. Prowler and Ernest W. Smith, Nov., 762

HEMOPOIETIC SYSTEM

- See also Bones, marrow; Spleen
- comparison of hematologic effects of internally deposited radium and plutonium in dogs, Jean H. Dougherty, John Z. Bowers, Robert C. Bay and Panit Keyanonda, Aug., 253

HEMOPTYSIS

- some serious complications of tuberculous lymph nodes: fatal hemoptysis, false aneurysm, occluded cisterna chyli and obstructive jaundice; review, with report of 5 cases (ab), Godfrey L. Gale, Sept., 462

HEMORRHAGE

- See also Placenta; Telangiectasis
- control of radiation hemorrhage with splenic extracts (ab), J. Philip Savitsky, Nov., 834

HEMOSIDEROSIS

- miliary pulmonary hemosiderosis in roentgenogram (ab), R. Haubrich and E. Versen, July, 126
- pulmonary hemosiderosis in mitral stenosis (ab), H. E. Taylor and G. F. Strong, Nov., 305

HEMOSTASIS

- in sympathectomized and adrenalectomized animals before and after total body x-irradiation (ab), Alfred L. Copley and Paul L. Stefkó, Oct., 651

HENYE, N. See TAKÁTS, L.**HERBERT, EARLE A.** See JACOBSON, HAROLD G.**HEREDITARY**

- See also Familial Conditions
- hereditary hemorrhagic telangiectasis; report of pulmonary arteriovenous fistulae in mother and son; medical (hormonal) and surgical therapy of this disease (ab), Edward C. Heyde, Sept., 466
- pulmonary arteriovenous telangiectasis (ab), Fred N. Mitchell, Nov., 802

HERMEL, MORTIMER B. See GERSHON-COHEN, JACOB**HERNIA**

- diaphragmatic**
 - congenital diaphragmatic hernia (ab), William L. Riker, July, 136
 - contribution to roentgenology of hiatus hernia and hiatus insufficiency (ab), Hans R. Beck, July, 136
 - diagnosis of hiatus hernia on plain roentgenograms of thorax and abdomen (ab), Francis J. O'Connor and Max Ritvo, Nov., 814
 - differential diagnosis of hiatus hernia: recurrent thromboses as symptom of hiatus hernia (ab), T. Wegmann, Sept., 472
 - fate of esophageal hiatus hernia: clinical and experimental study (ab), Joseph L. Sprafka et al., July, 137
 - further report on combination of diverticula in gastrointestinal tract with hiatal hernia (ab), J. Smulewicz, July, 130
 - hernia through esophageal hiatus simulating coronary pain; 50 cases (ab), Joe Holoubek et al., Nov., 813
 - incarcerated hernia; case (ab), Katharine Branson, Dec., 954
 - subcostosternal diaphragmatic hernia (ab), Karl F. Hoffmann and Alexander J. Chilko, July, 137
 - value of routine chest x-ray film in detecting hernia; 53 cases (ab), Abel Froman, Aug., 306

HERRMAN, R. W. See DICK, D. R.**HERSCHFUS, J. A.** See SALOMON, A.**HESLIN, J.** See HANBURY, E. M., Jr.

- HESSE, P., and BONMANN, K.-H.:** Radiotherapy of arthrosis, spondylosis, periarthritis humeroscapularis and epicondylitis (ab), Nov., 825

HEUSE, O. See RAJEWSKY, B.

- HEUWIESER, HEINZ:** Treatment of radiation sickness with sulfhydryl compounds and its problems (ab), Aug., 321

HEVESY, GEORGE. See FORSSBERG, ARNE G.

- HEYDE, EDWARD C.:** Hereditary hemorrhagic telangiectasia: a report of pulmonary arteriovenous fistulae in mother and son; medical (hormonal) and surgical therapy of this disease (ab), Sept., 466

HIATUS ESOPHAGEUS. See Hernia, diaphragmatic**HICKEY, ROBERT C.** See GIUS, JOHN A.

- HIDALGO, JOHN U., BURNS, EDGAR, and NIESET, ROBERT T.:** A technique for evaluating the effectiveness of localization of radioactive colloidal gold-198 after direct injection into tumors (ab), Aug., 318

HIGHBY, DOROTHY. See DETRICK, LAWRENCE E.**HIGINBOTHAM, NORMAN L.** See COLEY, BRADLEY L.**HILL, FRANCIS, KENNETH C.****HILL, MALCOLM.** See GLENN, FRANK**HILLEBOE, HERMAN E.** See ROACH, JOHN F.**HILLER, H. G.** See POWELL, M. L.**HILSCHER, W. M.:** Venous aneurysms (ab), Dec., 951**HILTEMANN, H.:** Moving field irradiation through a grid. A new method of roentgen therapy (ab), July, 150**HILTON, GWEN:** Breast carcinoma. The influence of a febrile illness on an arrested case (ab), Aug., 315**—See POCHIN, E. ERIC**

- HIMANKA, ERKKI, and LARSSON, LARS-GUNNAR:** Estimation of thyroid volume. An anatomic study of the correlation between the frontal silhouette and the volume of the gland (ab), Dec., 962

HINE, G. J., BURROWS, B. A., APT, L., POLLYCOVE, M., ROSS, J. F., and SARKIS, L. A.: Scintillation counting for multiple tracer studies (ab), Dec., 966**HINMAN, FRANK, Jr., MILLER, GERALD M., NICKEL, ELTON, STEINBACH, HOWARD L., and MILLER, EARL R.:** Normal micturition: certain details as shown by serial cystograms (ab), Nov., 821

- SCHULTE, JOHN W., and LOW-BEER, B. V. A.:** Further experience with intracavitary radiocobalt for bladder tumors (ab), Dec., 963

HIP

- protrusion of acetabulum (ab), Franco Mainoldi, Nov., 817
- slipping of upper femoral epiphysis: epiphysiolysis, epiphysiolsthesis, epiphysal separation or fracture, epiphysal coxa vara (ab), Carl E. Mosse, Aug., 307

diseases

- arthritis following urinary tract operation, Edwin L. Lame, Aug., 194
- bone cysts and osteoarthritis of hip (ab), Elvio Cecchi and Aligi Fumicelli, Sept., 478
- osteoarthritis: study of clinical pathology (ab), G. C. Lloyd-Roberts, Dec., 955

dislocations

- congenital dysplasia: observations on the "normal" joint in cases of unilateral disease (ab), S. L. Weissman, Aug., 307

tumors

- management of malignant disease in neighborhood of hip (ab), Bradley L. Coley and Norman L. Higinbotham, Oct., 643

HIRSCH, EUGENE Z. See MUELLER, RICHARD**HISTIOCYTOSIS.** See Reticuloendothelial System**HISTOPLASMOSIS**

- histoplasmosis of lungs (ab), Benjamin Schwartz, Oct., 627
- pulmonary histoplasmosis with cavitation (ab), Edith Mankiewicz et al., Sept., 463

HLAD, CHARLES J., Jr., and BRICKER, NEAL S.: Renal function and ¹³¹I clearance in hyperthyroidism and myxedema (ab), Oct., 647**HOCHBERG, LEW A.** See CRASTNOPOL, PHILIP**HOCHMANN, A.** See SCHORR, S.

- HODES, PHILIP J.:** Pitfalls in the roentgen diagnosis of pulmonary disease (ab), Aug., 291

—See JARVIS, LUTHER**HODGKIN'S DISEASE**

- (ab), Ralston Paterson and Edith Paterson, Oct., 643
- chemotherapy of leukemia, Hodgkin's disease and related disorders (comparison with radiotherapy) (ab), M. M. Wintrobe et al., July, 148
- manifestations of Hodgkin's disease of gastrointestinal tract (ab), U. V. Portmann et al., Sept., 468
- rare case of bony form of Hodgkin's lymphogranuloma (ab), O. Sovka et al., Nov., 815

HODGSON, JOHN R., and KENNEDY, ROGER L. J.: Roentgenologic aspects of chronic ulcerative colitis in children, Nov., 671**—See CRAIG, RICHARD M.**

- HOERR, STANLEY O.:** Operative cholangiography as an aid in surgery for jaundice (ab), July, 135

HOFFMAN, HARRY S.: Actinomycotic diverticuloma of the sigmoid colon (ab), July, 133**HOFFMANN, KARL F., and CHILKO, ALEXANDER J.:** Subcostosternal diaphragmatic hernia (ab), July, 137**HOFFMANN, TH.** See ROBERT, F.**HOL, RAGNAR, and SKJERVEN, ODD:** Spinal cord damage in abdominal aortography (ab), Aug., 299**HOLSH, S.:** Diagnosis of tumours of the glomus jugulare (ab), Nov., 798

- HOLLCROFT, JOANNE W., and MATTHEWS, MARION:** Lack of effect of adrenalectomy on tumor regression following x-irradiation (ab), Aug., 322

- HOLMAN, COLIN B., SVIEN, HENDRIK J., BICKEL, WILLIAM H., and KEITH, HADDOW M.:** Diastematomyelia (ab), Dec., 955
- HOLUBBEK, JOE, CARROLL, W. H., LANGFORD, RICHARD B., and RILEY, G. M.:** Hernia through the esophageal hiatus simulating coronary pain. Report of fifty cases (ab), Nov., 813
- HOOD, ROBERT T.** See **McBURNIE, ROBERT P.**
- HOPE, JOHN W., SPITZ, EUGENE B., and SLADE, HARRY W.:** Early recognition of premature cranial synostosis, Aug., 183
- HOPEMAN, ALAN R.** See **DOWNES, CHARLES R.**
- HORMONES**
See also Adrenocorticotrophic Hormone
—hereditary hemorrhagic telangiectasis: report of pulmonary arteriovenous fistulae in mother and son: medical (hormonal) and surgical therapy of this disease (ab), Edward C. Heyde, Sept., 466
—physical, physiological, and hormonal aspects of hydronephrosis (ab), P. G. Keates, Aug., 311
—somatotrophic. See Pituitary Preparations
- HORTON, CHARLES.** See **GEORGIADIS, NICHOLAS**
- HOSPITALS**
—case findings from routine chest roentgenograms. Mass surveys of communities versus general hospital admissions (ab), William Siegal et al., Nov., 799
—chest surveys: a symposium (value, especially in relation to routine hospital admissions), L. Henry Garland, Moderator, July, 19-30
—clinical survey of adenomas of trachea and bronchus in general hospital (ab), Lamar Soutter et al., Aug., 292
—experience with large routine chest film in rural hospital (ab), J. W. Boyd, Aug., 293
—hospital administrator looks at chest surveys, Ray E. Brown, July, 22
—photofluorographic detection of cardiovascular disease in a general hospital (ab), Harold D. Batt et al., Oct., 629
—program for roentgen examination of hospital admissions (ab), Caroline W. Rowe, Aug., 293
—radiation hazard evaluation and control in hospitals, G. Ferlazzo, T. Nicholson, A. Jacobson and M. Bushman, Dec., 892
—radiologist and chest surveys, T. J. Wachowski, July, 19
—routine chest films of hospital admissions from standpoint of specialist in diseases of chest, Edwin R. Levine, July, 24
- HOUGHTON, L. E., WALTER, J. B., and JONES, D. E. A.:** Inhibition of acute x-ray damage by cortisone (ab), Oct., 652
- HOWARD, JOHN M.:** Gall bladder function (cholecystographic studies) following nonspecific trauma. The systemic response to trauma (ab), Oct., 636
- HUANG, KEE-CHANG, ALMAND, JAMES R., and HARGAN, LILA A.:** The effect of total body x-irradiation on hepatic and renal function in albino rats (ab), Aug., 322
- HUGHES, E. S. R., and KERNUTT, R. H.:** Operative cholangiography (ab), July, 134
- HULTBERG, S.** See **BENNER, S.**
- HULTBORN, K. A., and FORSSBERG, A.:** Irradiation of skin tumours during pure oxygen inhalation (ab), Oct., 642
- and JONSSON, L. I.:** The use of colloidal Au¹⁹⁸ for the detection of lymph nodes in radical excision of the breast (ab), Dec., 903
- LARSSON, L.-G., and RAGNHULT, I.:** A study of the lymph drainage of the lower limb with the use of colloidal radiogold (Au¹⁹⁸) (ab), Dec., 904
The lymph drainage from the breast to the axillary and parasternal lymph nodes studied with the aid of colloidal Au¹⁹⁸ (ab), Nov., 829
- HULTGREN, HERBERT N.** See **ELDRIDGE, FREDERIC L.**
- HUMERUS**
—radiotherapy of arthrosis, spondylosis, periarthritis humero-scapularis and epicondylitis (ab), P. Hess and K. H. Bonmann, Nov., 825
- HUNGARY**
—law relating to work at x-ray installations in Hungary (ab), Josef Slanina, Nov., 834
- HUNTER, CURWOOD R., and MAYFIELD, FRANK H.:** The oblique view in cerebral angiography (ab), Nov., 795
- HURDLE, THOMAS G.** See **RAINES, SAMUEL L.**
- HUTAFF, LUCILE W., and BELDING, HELEN W.:** The effects of irradiation of the pelvis in patients with carcinoma of the cervix uteri on the iliac and sternal marrow and on the peripheral blood (ab), Dec., 967
- HYDROGEN, RADIOACTIVE.** See **RADIOACTIVITY**
- HYDROGEN PEROXIDE**
—barium in hydrogen peroxide in esophageal and gastric diagnosis, Cesare Gianturco and George A. Miller, Oct., 568
—retrograde pyelography with hydrogen peroxide in contrast medium: preliminary report (ab), Paavo Klami, July, 143
- HYDRONEPHROSIS**
—diagnosis by percutaneous renal puncture (ab), H. Stephen Weens and Thomas J. Florence, Aug., 311
—physical, physiological, and hormonal aspects (ab), P. G. Keates, Aug., 311
- HYDROXYLAMINE**
—effect of hydroxylamine and x-irradiation on red cell destruction and formation and serum iron concentration (ab), Alfred Chazotte and Elizabeth L. Word, Oct., 652
- HYMAN, JULIAN B., and EPSTEIN, FREDERICK H.:** A study of the correlation between roentgenographic and post-mortem calcification of the aorta (ab), Aug., 296
- HYPAQUE.** See **Pyelography**
- HYPERCALCAEMIA.** See **Urine and Urination**
- HYPERTENSION.** See **Blood Pressure**
- HYPOPHARYNX.** See **Pharynx**
- HYPOPHYSICTENY.** See **Pituitary Body**
- HYSTERECTOMY.** See **Uterus**
- HYSTEROSALPINGOGRAPHY.** See **Fallopian Tubes**

I

- IDBOHRN, HANNS:** Renal angiography in cases of delayed excretion in intravenous urography (ab), Sept., 480
- ILBERY, PETER:** Fistulous imperforate anus (ab), Sept., 472
- ILEUM.** See **Intestines**
- ILEUS.** See **Intestines, obstruction**
- ILIUM.** See **Bones, marrow**
- IMAGE AMPLIFICATION.** See **Roentgen Rays, fluoroscopy**
- IMBER, IRVING, and CLYMER, ROBERT H., Jr.:** Obstruction of internal artery producing malignant hypertension (ab), Dec., 957
- IMMERMAN, LEWIS L.** See **BELL, A. L. L.**
- IMMUNITY**
See also Antibodies; Trichinella
—effects of ionizing radiation on immunity (ab), William H. Hale and Richard D. Stoner, Aug., 321
- INCUBATOR**
—technic for roentgenographic examination of newborn, premature, or ill infants without removal from incubator (ab), Henry K. Silver and William L. Nyhan, Oct., 641
- INCUS.** See **Ear**
- INDUSTRY AND OCCUPATIONS**
—diseases and poisoning. See also Pneumoconiosis
—ornithosis as an occupational hazard, Bernard Rosen, Sept., 373
- INFANTS.** See **Children; Infants, Newborn**
- INFANTS, NEWBORN**
—distribution of air in intestinal tract of infants during first twelve hours as determined by serial roentgenograms (ab), Morton L. Podolsky and Albert W. Jester, Oct., 635
—osteomyelitis in newborn (ab), C. M. C. Potter, Sept., 474
—radioactive iodide uptake of normal newborn infants (ab), L. Van Middlesworth, Aug., 316
—retroperitoneal cavernous hemangioma associated with hemangiomas of skin in a newborn: case report and brief review of literature (ab), J. Richards Aurelius et al., Nov., 812
—technic for roentgenographic examination of newborn, premature, or ill infants without removal from incubator (ab), Henry K. Silver and William L. Nyhan, Oct., 641
- INFECTIONS**
See also Urinary Tract
—effects of ionizing radiation on immunity (ab), William H. Hale and Richard D. Stoner, Aug., 321
—pathogenesis and pathology of post-irradiation infection (ab), V. P. Bond et al., Aug., 321
—susceptibility of irradiated animals to infection (ab), I. L. Shechmeister, Aug., 321
—treatment of post-irradiation infection (ab), Carolyn W. Hammond, Aug., 321
- INGBAR, SIDNEY H.:** Simultaneous measurement of the iodine concentrating and protein-binding capacities of the normal and hyperfunctioning human thyroid gland (ab), Dec., 902
- INGELFINGER, FRANZ J., KRAMER, PHILIP, and SANCHEZ, GUILLERMO C.:** The gastroesophageal vestibule, its normal function and its role in cardiospasm and gastroesophageal reflux (ab), Aug., 301
- INGLEBY, HELEN.** See **GERSHON-COHEN, JACOB**
- INJURIES.** See **Athletics**
- INSULIN**
—effects of thyroid function on insulin-I¹³¹ degradation (ab), Neil J. Elgee and Robert H. Williams, Nov., 829
—insulin-induced hypermotility in roentgen examination of stomach and duodenum, Denis C. Adler, George Jacobson, Kenneth A. Heitmann and Derrell D. Watson, Oct., 530
—pituitary and adrenal influences on insulin-I¹³¹ degradation (ab), Neil J. Elgee and Robert H. Williams, Nov., 829
- INTER-AMERICAN CONGRESS OF RADIOLOGY (Fifth),** July, 113
- INTERNATIONAL CONGRESS OF RADIOLOGY**
seventh
—recommendations on units and protection, Nov., 787
eighth, Oct., 614; Nov., 786
- INTERNATIONAL CONGRESS ON DISEASES OF CHEST** (fourth), Nov., 787
- INTESTINES**
See also Colon; Gastrointestinal Tract
—late results of bladder substitution with isolated ileal segments (ab), Eugene M. Bricker et al., Aug., 312
—rate of absorption of water from stomach and small bowel of human beings (ab), John F. Scholer and Charles F. Code, Sept., 470
- CYSTS**
—abdominal gas cysts complicated by intestinal obstruction (ab), Albert J. Kukral et al., Nov., 811
—pneumatosis cystoides intestinalis in infancy (ab), Leonard Paris, Nov., 810

INTESTINES—cont.

- diseases
- amyloidosis of small intestine (ab), Ross Golden, July, 132
 - diverticula. See also Epiploic Appendages
 - correlation of clinical, pathological and roentgenological findings (ab), Alexander Goulard, Jr., and Aubrey O. Hampton, July, 133
 - diverticulitis and carcinoma of colon: differential diagnosis (ab), Bentley P. Colcock and Robert E. Sass, Sept., 471
 - ectopic gastric mucosa in a congenital small bowel diverticulum: roentgen demonstration and report of case, Warren L. Kump, Joseph Jorgens and Leo G. Rigler, July, 81
 - Meckel's diverticulum, with emphasis on the roentgen diagnosis, Martin E. Bischoff and Wendell P. Stampfli, Oct., 572
- fistula. See Fistula
- obstruction. See also Intussusception
- abdominal gas cysts complicated by obstruction (ab), Albert J. Kukral et al. Nov., 811
 - administration of barium orally in acute obstruction: advantages and risks (ab), J. Frimann-Dahl, Aug., 302
 - microcolon and meconium ileus (ab), G. Candardjis and F. Saegesser, Sept., 471
 - of small intestine in infants and children: roentgenologic and pathologic study (ab), Richard M. Craig et al, July, 131
 - suggestive x-ray sign of strangulation in obstruction (ab), Frank J. Rack and Norman Glazer, July, 131
- roentgenography
- application of silicones to roentgenology of colon: a pilot study, Theodore E. Keats and Robert M. Whitrock, Oct., 578
 - detection of small lesions of large bowel: barium enema versus double contrast (ab), J. Maurice Robinson, Sept., 470
 - distribution of air in intestinal tract of infants during first twelve hours as determined by serial roentgenograms (ab), Morton L. Podolsky and Albert W. Jester, Oct., 635
 - ileum following colectomy, Samuel H. Madell and Ross Golden, Oct., 539
 - roentgen abnormalities of the large and small intestine associated with prolonged cathartic ingestion, Norman Heilbrun and Charles Bernstein, Oct., 549
 - roentgen studies of effects on small intestine from emotional disturbances (ab), Jack Friedman, July, 132
 - roentgen studies of small intestine in sprue (ab), Richard H. Marshak et al, July, 131
- tuberculosis
- indications for x-ray examination in patients with pulmonary tuberculosis (ab), H. Erdmann, Aug., 303
- tumors
- malignant melanoma of small intestine, Michael F. Beirne, Nov., 749
- ulcers
- pathogenesis of ulcers following irradiation: effects of colostomy and adhesions (ab), Nathan B. Friedman, Nov., 831
- volvulus
- detorsion of volvulus of right colon: roentgenographic considerations (ab), Leo S. Figiel and Steven J. Figiel, July, 133
 - of cecum (ab), Thomas F. Rose, Sept., 471
- INTUSSUSCEPTION
- (ab), Ira S. Goldenberg, Aug., 302
 - barium reduction of intussusception in infancy (ab), Edward J. Denenholz and George S. Feher, Nov., 811
 - 8 year survey (ab), Grosvenor T. Root et al, Dec., 952
 - gastrointestinal intussusception, Howard Mauthe and George Zwicky, July, 86
 - gastro-gastric intussusception; 2 cases (ab), Clerio Di Carlo, July, 130
 - reduction by barium enema (ab), Mark M. Ravitch, Aug., 303
 - retrograde intussusception at gastrojejunal stoma; 2 cases and a bibliography (ab), Eddy D. Palmer, Sept., 469
- IODINE AND IODINE COMPOUNDS
- fat absorption test using iodized oil, with particular application as a screening test in diagnosis of fibrocystic disease of pancreas (ab), Frederic N. Silverman and Harry C. Shirley, Dec., 954
 - intravenous urography using mixtures of radiopaque agents (Neo-Iopax, Diodrast, Urokon), Benedict R. Harrow, Aug., 265
 - study of clinical reactions to venous angiocardiology (ab), Frederic L. Eldridge et al, Dec., 950
- radioactive. See Radioactivity; Thyroid
- IONIZATION CHAMBERS
- investigation of grid fields with miniature ionization chamber (ab), W. R. Bruce and H. E. Johns, July, 150
- IRON, RADIOACTIVE. See Radioactivity
- ISAACS, AVROM M. See BERG, HAROLD F.
- ISODOSE CURVES. See Roentgen Therapy
- ISONIAZID. See Tuberculosis, Pulmonary
- ISOTOPES. See Radioactivity; Thyroid
- ITNER, WILLIAM B., III. See SEAMAN, WILLIAM B.
- IVALON PACK. See Tuberculosis, Pulmonary, therapy

J

- JACCARD, G. See LÖFFLER, W.
- JACK, E. A.: Bone anomalies of the tarsus in relation to "peroneal spastic flat foot" (ab), Sept., 479

- JACKSON, W. P. U., ALBRIGHT, FULLER, DREWRY, GARTH, HANELIN, JOSEPH, and RUBIN, MITCHELL I.: Metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. I. Familial metaphyseal dysplasia and craniometaphyseal dysplasia; their relation to leontiasis ossea and osteopetrosis; disorders of "bone remodeling" (ab), Oct., 636
- HANELIN, JOSEPH, and ALBRIGHT, FULLER: Metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. II. Multiple epiphyseal dysplasia; its relation to other disorders of epiphyseal development (ab), Oct., 637
- Metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. III. Progressive diaphyseal dysplasia (ab), Oct., 637
- JACOBS, MELVILLE L.: Use of radioactive chromic phosphate in pleural effusions (ab), Aug., 317
- JACOBSON, A. See FERLAZZO, G.
- JACOBSON, GEORGE. See ADLER, DENIS C.
- JACOBSON, HAROLD G., HERBERT, EARLE A., and POPPEL, MAXWELL H.: Arthrogryposis multiplex congenita, July, 8
- See POPPEL, MAXWELL H.
- JACOBSON, LILLIAN E., and KNAUER, ISABELLE S.: Stray radiation measurements around a cobalt 60 beam therapy installation (ab), Dec., 963
- JAFFE, BERTHA. See McCORMICK, JAMES B.
- JAFFE, HENRY L. See POBIRS, FREDERICK W.
- See ROTHENBERG, SANFORD F.
- See RUSCHE, CARL
- JAKOB, A.: Bone changes in trophic disorders of the leg (ab), Nov., 818
- JALLUT, O., PEGUIRON, L., FEISSLY, R., and NEUKOMM, S.: Research on the utilization of radioactive ^{45}Ca in colloidal solution for the determination of circulating blood volume (ab), July, 153
- JAMIESON, KENNETH G.: Rupture of an intracranial aneurysm during cerebral angiography (ab), Sept., 459
- JANUS, WILLIAM L. See STEPHENS, HUGH
- JACQUE, WILLIAM E. See WHEELER, H. BROWNELL
- JARVIS, LUTHER, and HODES, PHILIP J.: Aneurysm of the hepatic artery demonstrated roentgenographically. A case report (ab), Oct., 632
- JAUNDICE
- operative cholangiography as aid in surgery for jaundice (ab), Stanley O. Hoerr, July, 135
 - some serious complications of tuberculous lymph nodes: fatal hemoptysis, false aneurysm, occluded cisterna chyli and obstructive jaundice; review, with report of 5 cases (ab), Godfrey L. Gale, Sept., 462
- JAWS
- carcinomatous invasion of jaw bones roentgenographically considered, Robert S. Sherman and Florence C. H. Chu, Oct., 581
 - laminagraphy in acute maxillofacial injuries, Richard F. McClure, Sept., 408
 - roentgen appearance of adamantinoma of mandible, Robert S. Sherman and Hugh Caumartin, Sept., 361
 - technic for visualization of mental foramen; case of expanding soft tissue tumor in mental foramen (ab), G. Mårtensson and S. Ydén, Aug., 291
- JEJUNUM. See Intussusception; Peptic Ulcer
- JENSEN, H. See BOTKIN, A. L.
- JESTER, ALBERT W. See PODOLSKY, MORTON L.
- JOHANSON, C.-E. See YLINEN, OLLI
- JOHNS, H. E., TILL, J. E., and CORMACK, D. V.: Electron energy distribution produced by gamma-rays (ab), Aug., 324
- See BRUCE, W. R.
- JOHNSON, JOHN L. See SOBIN, SIDNEY S.
- JOHNSON, ROBERT B., and BAKER, HARVEY W.: Solitary calculus of the duct of Wirsung (ab), Oct., 636
- JOHNSON, WILLIAM E. See COMPERE, EDWARD L.
- JOHNSTON, M. HARLAN, and STUBBS, GEORGE M.: Sigmoidenteric fistula complicating diverticulitis. Report of a case (ab), Nov., 811
- JOINTS
- See also under names of joints, as Hip; Shoulder; etc.
 - atrophy of auricular and nasal cartilages following administration of chorionic gonadotrophins in case of arthritis mutilans with sicca syndrome (ab), Fred B. Rogers and John Lansbury, Nov., 797
 - Ehlers-Danlos syndrome with ectopic bone formation, Isadore Katz and Karl Steiner, Sept., 352
- ankylosis
- arthrogryposis multiplex congenita, Harold G. Jacobson, Earle A. Herbert and Maxwell H. Poppel, July, 8
 - surgical correction of eventration of diaphragm in patient with arthrogryposis; observations on cardiac manifestations of traction on diaphragm (ab), Philip Crastnopol et al, Nov., 813
- JONES, CHESTER M. See CHAPMAN, WILLIAM P.
- JONES, D. E. A. See HOUGHTON, L. E.
- JONES, MALCOLM D. See LINDSAY, STUART
- JONSSON, LARS. See LARSSON, LARS-GUNNAR
- JONSSON, L. I. See HULTBORN, K. A.
- JORGENSEN, JOSEPH. See KUMP, WARREN L.
- JORGSHOLM, B. See NIELSEN, JENS
- JOSEPH, J.: Range of movement of the great toe in men (ab), Aug., 308

JUGULAR BODY

- diagnosis of tumors of glomus jugulare (ab), S. Holesh, Nov., 798

K

- KALMON, EDMOND H., ALBERS, DONALD D., and DUNN, J. HARTWELL:** Ureteral jet phenomenon. Stream of opaque medium simulating an anomalous configuration of the ureter, Dec., 933

KAOLIN

- pneumocoinosis from exposure to kaolin dust: kaolinoses (ab), Kenneth M. Lynch and Forde A. McIver, Sept., 463
- KAPLAN, ALBERT D., and WALKER, A. EARL:** Complications of cerebral angiography (ab), July, 125

- KAPOSI'S SARCOMA.** See Sarcoma, Kaposi's

- KARJORIIS, FRANK G.** See COWAN, IRVING I.

- KARLSSON, K., ENGSTRÖM, A., and ENGSTRÖM, H.:** Microradiographic studies of the auditory ossicles (malleus and incus) and of the osseous labyrinth, Sept., 462

- KATZ, ISADORE:** A radiolucent pneumatic compressor for mucosal studies, Aug., 271

- and **STEINER, KARL:** Ehlers-Danlos syndrome with ectopic bone formation, Sept., 352

- KATZEN, PERRY, and TRACHTMAN, BENJAMIN:** Diagnosis of vaginal ectopic ureter by vaginogram (ab), Sept., 481

- KATZEV, HERBERT, and BASS, HYMAN E.:** Cavitation in metastatic pulmonary neoplasm (ab), Dec., 947

- KEATES, P. G.:** Physical, physiological, and hormonal aspects of hydronephrosis (ab), Aug., 311

- KEATS, THEODORE E.:** Generalized pulmonary emphysema as an isolated manifestation of early cystic fibrosis of the pancreas, Aug., 223

- and **CRANE, JACKSON F.:** Cystic changes of the lungs in histiocytosis (ab), Oct., 627

- See **STEINBACH, HOWARD L.**

- and **WHITROCK, ROBERT M.:** The application of silicones to roentgenology of the colon. A pilot study, Oct., 578

- KEEN, P.** See **ALLAN, J. C.**

- KEITH, HADDOW M.** See **HOLMAN, COLIN B.**

- KELLEY, GURNEY E.** See **BOYD, DAVID P.**

- KELLEY, JOHN P.** See **TROUT, E. DALE**

- KELSEY, DAVID C., and SPROAT, HARRY F.:** Echinococcus disease of bone. Report of a case (ab), Oct., 637

- KELLY, ROBERT P.** See **LEIGH, TED F.**

KELOID

- management in South African Bantu (ab), J. C. Allan and P. Keen, Oct., 646

- KENNEDY, R. J.** See **MILLER, WILLIAM**

- KENNEDY, ROGER L. J.** See **HODGSON, JOHN R.**

- KENT, EDWARD M., MOSES, CAMPBELL, FORD, WILLIAM B., KUTZ, EUGENE R., and GEORGE, ROBERT S.:** Radioactive isotopes in management of carcinomatosis of serous body cavities (ab), July, 151

- KERN, ARTHUR B.** See **RONCHESE, FRANCESCO**

- KERNUTT, R. H.** See **HUGHES, E. S. R.**

- KERR, FRED W. L., SCHWARTZ, HENRY G., and SEAMAN, WILLIAM B.:** Experimental effects of radioactive colloidal gold in the subarachnoid space. Clinical application in treating brain tumors (ab), Sept., 487

- KERWIN, A. J.:** Ebstein's anomaly: report of a case diagnosed during life (ab), Nov., 805

- KESHISHIAN, JOHN M., and SPENCER, WILLIAM A.:** Visualization of the inferior vena cava as an adjunct to diagnosis of retroperitoneal tumors. A case report (ab), Oct., 630

- KEY, J. ALBERT.** See **FORD, LEE T.**

- See **ODELL, RICHARD T.**

- KEYANONDA, PANIT.** See **DOUGHERTY, JEAN H.**

KIDNEYS

- See also Hydronephrosis

- effect of total-body x-irradiation on hepatic and renal function in albino rats (ab), Kee-Chang Huang et al., Aug., 322

- foreign body in left kidney and ureter (ab), Bela Gondos, Nov., 821

- osteosclerosis associated with chronic renal failure (ab), T. Crawford et al., Nov., 814

- renal function and I^{131} clearance in hyperthyroidism and myxedema (ab), Charles J. Hlad, Jr., and Neal S. Bricker, Oct., 647

abnormalities

- congenital solitary pelvic kidney: a study of its blood supply by aortography (ab), U. Borell and I. Fernström, Aug., 310

- renal anomalies: a source of confusion in diagnosis of abdominal disease (ab), T. Burton Smith, Aug., 310

- blood supply.** See also Kidneys, abnormalities; Kidneys, tumors

- anatomy of intrarenal arteries and its application to segmental resection of kidney (ab), F. T. Graves, July, 143

- angiographic study of renal circulation in experimental hypertension in dog (ab), P. M. Daniel et al., July, 143

- hypertension in infancy, with anomalous renal artery: diagnosis by renal arteriography, apparent cure after nephrectomy (ab), C. Harrison Snyder et al., Nov., 808

- importance of serial aortography for demonstration of blood vessels in pelvis and kidney (ab), K. E. Loose, Sept., 480

- obstruction of renal artery producing malignant hypertension (ab), Irving Imber and Robert H. Clymer, Jr., Dec., 957

- renal angiography in cases of delayed excretion in intravenous urography (ab), Hans Idbohrn, Sept., 480

- renal arteriography (ab), Arthur T. Evans, Aug., 310

- venous junction of glomerular artery (ab), Armando Trabucco and Fernando Márquez, Oct., 631

calcification

- nephrocalcinosis visible by x-ray associated with chronic glomerulonephritis (ab), Walter L. Arons et al., Dec., 957

calculi

- urinary tract calculi in children: renal and vesical calculi in an 8-month-old child (ab), C. A. Moore and C. C. Dodson, Oct., 640

cancer

- irradiation therapy in urology: the kidney (ab), E. W. Riches, Oct., 644

cysts

- bilateral polyadenomatous kidneys: adenomatosis of kidneys simulating polycystic disease (ab), Herman J. Meisel, Oct., 640

diverticula

- calyceal diverticula (ab), Robert J. Banker and William H. Card, Sept., 481

fistula. See Fistula

lipids. See Lipids

pathology

- renal changes in paraplegia as screened by routine excretory urography (ab), A. Estin Comarr, Aug., 311

roentgenography. See also Pyelography

- abdominal aortography, with special reference to kidney diseases (ab), Rolf Weyde, Sept., 480

- aortography (ab), J. Sydney Ritter, Nov., 806

- aortography: further experiences (ab), Ian F. Potts, Dec., 956

- surgery.** See Kidneys, blood supply

tumors

- bilateral polyadenomatous kidneys: adenomatosis of kidneys simulating polycystic disease (ab), Herman J. Meisel, Oct., 640

- diagnosis of adenoma (ab), Jan Kučera and Čestmír Dvořáček, Nov., 822

- tumor not demonstrable by urography but shown by renal angiography (ab), P. Olov Löfgren, Aug., 311

- KIERLAND, ROBERT R.** See **BRUWER, ANDRÉ J.**

- KINSELLA, V. J.:** The neglect of the gastro-duodenal mucosa by clinicians and radiologists (ab), Sept., 468

- KIRCHHOFF, H. W.:** Use of tomography for unexplainable infiltrations in the upper mediastinum of infants (ab), Aug., 294

- KIRKLIN, JOHN W.** See **McBURNIE, ROBERT P.**

- KIRSNER, JOSEPH B.** See **LEVIN, ERWIN**

- KIRTLAND, HOWARD B., Jr.** See **BOYD, DAVID P.**

- KISFALUDY, P., VÁNDOR, F., and TEMESVÁRI, A.:** Treatment of malignant tumors of the tonsillar region and soft palate (ab), Nov., 826

- KLAMI, PAAVO:** Retrograde pyelography with hydrogen peroxide in the contrast medium. Preliminary report (ab), July, 143

- KLASSEN, KARL P.** See **SMITH, PHILIP W.**

- KLEIN, I.:** An improved x-ray stand, Sept., 420

- KLÍMA, JOSEF:** Agenesis of the lungs (ab), Nov., 799

- KNAUER, ISABELLE S.** See **JACOBSON, LILLIAN E.**

KNEE

- chronic coccidioidal synovitis (ab), Federico Sotelo-Ortiz, Nov., 818

roentgenography

- analysis of roentgenograms (ab), G. Teichert, Nov., 818

- opaque arthrography: study of series of 100 examinations (ab), Claude Lagarde, July, 141

- KNISELEY, RALPH M.** See **ROOT, SAMUEL W.**

- KNORPP, CHARLES T.** See **HAVENER, WILLIAM H.**

- KNOUFF, RALPH A.** See **ACKERMAN, G. ADOLPH**

- KNUDTSON, KENNETH P.** See **BOGARDUS, GEORGE M.**

- KOBERG, H.:** Necessity for water-soluble contrast media for lumbar myelography (ab), Dec., 955

- KOK-v. ALPHEN, C. C.** See **SCHOLTE, P. J. L.**

- KOTSCHER, E.:** Spontaneous subluxation of the atlantoaxial joint with inflammatory processes in the neck (ab), Nov., 797

- KOVACS, ÁKOS:** Subluxation and deformation of the cervical apophyseal joints: a contribution to the aetiology of headache (ab), Nov., 816

- KRAMER, PHILIP:** The adverse effects of belladonna alkaloids in benign pyloric obstruction. An experimental study (ab), July, 139

- See **INGELFINGER, FRANZ J.**

- KRISS, JOSEPH P., BIERMAN, HOWARD R., THOMAS, SYDNEY F., and NEWELL, ROBERT R.:** Treatment of multiple myeloma with radioactive iodine and radioactive iodinated serum albumin, Aug., 241

- CARNES, WILLIAM H., and GROSS, RUTH T.:** Hypothyroidism and thyroid hyperplasia in patients treated with cobalt (ab), Nov., 829

- KROHMER, JACK S.** See **THOMAS, CHARLES I.**

- KROOP, IRVING G.** See **CRASTNAPOL, PHILIP**

- KUČERA, JAN, and DVOŘÁČEK, ČESTMÍR:** A contribution to the diagnosis of renal adenoma (ab), Nov., 822

- KUGEL, E., and PÖSCHL, M.:** Pulmonary tuberculoma: roentgen diagnostic and therapeutic considerations (ab), Dec., 948

- KUKRAL, ALBERT J., PLANK, J. R., and DENST, JOHN:** Abdominal gas cysts complicated by intestinal obstruction (ab), Nov., 811
- KULP, J. LAURENCE:** Low-level counting, key to advances in radiocarbon dating (ab), Oct., 648
- KUMP, WARREN L., JORGENSEN, JOSEPH, and RIGLER, LEO G.:** Ectopic gastric mucosa in a congenital small bowel diverticulum. Roentgen demonstration and a report of a case (ab), July, 81
- KUNSTADTER, RALPH H., and TULSKY, ALEX:** Diagnostic transabdominal pneumoperitoneum in children (ab), July, 142
- KURLAND, GEORGE S. See BLUMGART, HERRMAN L.**
- KUTZ, EUGENE R.:** The radiotherapeutic test: an unreliable diagnostic procedure in intrathoracic mass lesions, Sept., 378
- See **KENT, EDWARD M.**
- KYLLÖNEN, K. E. J. See PERÄSALO, O.**
- L**
- LABYRINTH. See Ear**
- LACRIMAL ORGANS**
- osseous lacrimal pathway: the possibilities of its radiologic exploration (ab), J. Porot and J. Cl. Levasseur, Nov., 790
- LAGARDE, CLAUDE:** Opaque arthrography of the knee. A study of a series of 100 examinations (ab), July, 141
- LAHR, T. N., OLSEN, ROBERT, GLEASON, G. I., and TABERN, D. L.:** Animal distribution of colloids of Au¹⁹⁸, P³², and Y⁹⁰: an improved method of tissue assay for radioactivity (ab), Oct., 649
- LAJTHA, L. G., and SUIT, H. D.:** Uptake of radioactive iron (⁵⁹Fe) by nucleated red cells in vitro (ab), Nov., 830
- LALLI, ANTHONY, CARLSON, RALPH F., and ADAMS, W. E.:** Intralobar pulmonary sequestration. Report of three cases, with two additional cases of agenesis of the right upper and middle lobes in combination with anomalous systemic vessels (ab), Oct., 626
- LAMB, DOUGLAS W.:** Localized osteochondritis of the lumbar spine (ab), Sept., 478
- LAME, EDWIN L.:** Arthritis of the hip following urinary tract operation, Aug., 194
- LAMERTON, L. F. See BAXTER, C. F.**
- LAMINAGRAPHY. See Body-Section Roentgenography**
- LAMSON, BALDWIN G. See TULLIS, JOHN L.**
- LANDGRAF, F.-K.:** Acromial apophysitis, a rare osteochondropathy (ab), Oct., 639
- LANE, F. W., Jr. See MacCARTY, W. C., Jr.**
- LANGER, E., and WILLMANN, K. H.:** Contribution to the so-called alveolar-cell carcinoma (pulmonary adenomatosis) (ab), Nov., 801
- LANGER, EDWARD M. See FELD, HAROLD**
- LANGFORD, RICHARD B. See HOLOUBEK, JOE**
- LANGSAM, MARTIN, and WILENSKY, NATHAN D.:** An apparatus for automatic introduction of radiopaque media in translumbar aortography (ab), Aug., 312
- LANGTON, L., and LAWS, J. W.:** Dysphagia in carcinoma of the pancreas (ab), Aug., 304
- LANSBURY, JOHN. See ROGERS, FRED B.**
- LARSSON, LARS-GUNNAR, and JONSSON, LARS:** Continuous registration of thyroid uptake after intravenous injection of radioactive iodine. A rapid test of iodine concentrating function of the thyroid (ab), Nov., 827
- See **HIMANKA, ERKKI**
- See **HULTBORN, K. A.**
- LARYNX**
- cancer
- experiences at Zürich with radiotherapy of laryngeal and hypopharyngeal carcinoma, with reference to the new international staging classification (ab), K. Schärer, July, 146
- present-day indications for treatment of tumors of oral cavity, larynx and pharynx (ab), A. Zuppinger, Aug., 314
- LASSER, ELLIOTT C., and STENSTROM, E. WILHELM:** Radiation sickness: a study of its relation to adrenal cortical function and the absolute eosinophil count (ab), July, 154
- The effect of Cortate and of Dramamine on a selected group of patients undergoing deep roentgen therapy for carcinoma of the cervix uteri (ab), Sept., 487
- LATOURETTE, H. B. See DODDS, J. R.**
- LATOURRETTE, H. B. See HAAS, R. L.**
- LAUGHLIN, J. S. See GENNA, S.**
- LA VIOLETTE, DUANE. See RAY, ROBERT D.**
- LAWRENCE, L. R. See POPPEL, MAXWELL H.**
- LAWS, J. W. See LANGTON, L.**
- LEAD**
- lead EDTA complex: a water soluble contrast medium (ab), N. Sapeika, July, 145
- lead EDTA complex: further radiographic studies (ab), N. Sapeika, July, 145
- lead calcium EDTA (ab), N. Sapeika, July, 145
- x-ray attenuation in lead, aluminum, and concrete in the range 275 to 525 kilovolts, William Miller and R. J. Kennedy, Dec., 929
- LEAHY, WILLIAM V. C., MCKICKLE, THOMAS F., and SMITH, PAUL K.:** Fate of injected radiophosphorus-labeled leucocytes (ab), Oct., 648
- LECHER, B. DOUGLAS. See ALPERT, MEYER**
- LEE, SAMUEL. See McKIBBEN, BYRON G.**
- LEFFERTS, DAVID, BERANBAUM, SAMUEL L., and GOTTLIB, CHARLES:** Gastric volvulus. Part II. Idiopathic gastric volvulus (ab), Aug., 301
- See **BERANBAUM, SAMUEL L.**
- See **GOTTLIB, CHARLES**
- LEGS**
- See also **Extremities**
- bone changes in trophic disorders of leg (ab), A. Jakob, Nov., 818
- LEIGH, TED F., KELLY, ROBERT P., and WEENS, H. STEPHEN:** Spinal osteomyelitis associated with urinary tract infections, Sept., 334
- LEINFELDER, P. J., EVANS, T. C., and RILEY, E.:** Production of cataracts in animals by x-rays and fast neutrons, Sept., 433
- LEIOMYOMA. See Tumors, myoma**
- LEITNER, BALDO:** Mechanism of total dislocation of the talus (ab), Nov., 819
- LEMAK, LESLIE L., WIGBY, PALMER E., and MARTIN, JOHN E.:** Peptic ulcer in children (ab), Sept., 469
- LENS, CRYSTALLINE**
- differential radiophosphorus uptake of lens (ab), William H. Havener and Charles T. Knorr, Oct., 648
- LEONTIASIS OSSIIUM**
- metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. I. Familial metaphyseal dysplasia and craniometaphyseal dysplasia; their relation to leontiasis ossea and osteopetrosis; disorders of "bone remodeling" (ab), W. P. U. Jackson et al, Oct., 636
- LEOPOLD, I. H. See EISENBERG, I. J.**
- LEPAUL, G. See GERNEZ-RIEUX, CH.**
- LEROY, GEORGE V.:** Clinical research using compounds with labeled radioactive carbon and hydrogen as tracers (ab), Dec., 966
- LEUKEMIA**
- chemotherapy of leukemia, Hodgkin's disease and related disorders (comparison with radiotherapy) (ab), M. M. Wintrobe et al, July, 148
- incorporation of radioactive L-cystine and L-methionine by leukemic leukocytes in vitro (ab), Austin S. Weisberger et al, Oct., 649
- incorporation of radioactive L-cystine by normal and leukemic leukocytes in vivo (ab), Austin S. Weisberger and Bennett Levine, Oct., 649
- LEUKOCYTES**
- See also **Leukemia**
- effect of granulocyte count and litter on survival of irradiated mice (ab), Willie W. Smith et al, Aug., 323
- fate of injected radiophosphorus-labeled leukocytes (ab), William V. C. Leahy et al, Oct., 648
- incorporation of radioactive L-cystine by normal and leukemic leukocytes in vivo (ab), Austin S. Weisberger and Bennett Levine, Oct., 649
- LEUKOTOMY. See Brain, surgery**
- LEVASSEUR, J. CL. See POROT, J.**
- LEVENE, GEORGE, BURKE, EDWARD N., and ARNOIS, DOLORES C.:** Roentgenologic diagnosis of aneurysm of the thoracic aorta, with particular reference to study in the right posterior oblique position (ab), Oct., 629
- LEVIN, ERWIN, PALMER, WALTER L., and KIRSNER, JOSEPH B.:** Observations on the diagnosis, treatment, and course of gastric ulcer. Evaluation of gastric irradiation as an adjunct in medical treatment (ab), Oct., 646
- LEVIN, WILLIAM C. See BLOCKER, T. G., Jr.**
- LEVINE, BENNETT. See WEISBERGER, AUSTIN S.**
- LEVINE, EDWIN R.:** Chest survey. Routine chest films of hospital admissions from the standpoint of the specialist in diseases of the chest, July, 24
- LEVINE, MORRIS H., and CROSBIE, STANLEY:** Value of a routine abdominal film (ab), July, 145
- LEVISON, V. B. See RAVEN, RONALD W.**
- LEVITT, S., and SAINT, ERIC G.:** Primary peptic ulceration of the jejunum (ab), Nov., 810
- LEWIS, GEORGE C., Jr., CHAMBERLAIN, RICHARD H., HALE, JOHN, and PAYNE, FRANKLIN L.:** A study of radiation dosimetry in the treatment of cervical cancer (ab), Oct., 643
- LEWIS, LENA A.:** Effect of repeated injections of Thorotrast on antibody production (ab), Oct., 652
- LEWIS, S. R. See BLOCKER, T. G., Jr.**
- LIBBY, RAYMOND L. See MOORE, VINCENT**
- LICHSTEIN, JACOB:** Differential diagnosis of benign prolapse of gastric mucosa (ab), Nov., 809
- LIGHT, A. W. See WILLIS, G. C.**
- LILLEHEI, C. WALTON. See SPELLMAN, MITCHELL W.**
- LIN, PAUL M., and SCOTT, MICHAEL:** Collateral circulation of the external carotid artery and the internal carotid artery through the ophthalmic artery in cases of internal carotid artery thrombosis. Report of five cases, Nov., 753
- LIND, JOHN, SPENCER, ROWENA, and WEGELIUS, CARL:** Diagnosis of cardiac shunts by intravenous angiocardiology (ab), Aug., 296
- LINDBLOM, KNUT:** On microtomography (ab), Oct., 641
- Rotation tomography at small angles (ab), Nov., 823
- LINDELL, BO:** Roentgen dose measurements on a radiation of very high intensity (ab), Sept., 483
- LINDGREN, GUNNAR, and ODEN, SVEN:** Heart volume determination on microfilms (ab), Sept., 463
- LINDGREN, MARTIN. See GEDDA, PER O.**

- LINDSAY, STUART, DAILEY, MORRIS E., and JONES, MALCOLM D.:** Histologic effects of various types of ionizing radiation on normal and hyperplastic human thyroid glands (ab), Aug., 320
- See **MILLER, EARL R.**
- INITIS PLASTICA.** See Stomach, cancer
- LIPIDS.** See Lipoids
- LIPPOCHONDRODYSTROPHY**
- gargolism with cardiovascular involvement in two brothers (ab), R. W. Emanuel, Aug., 295
- LIPIDS**
- effect of whole-body x-irradiation on lipids in liver, kidney, and spleen of fasted rats (ab), W. E. Cornatzer et al, Nov., 832
- LIPOSARCOMA.** See Sarcoma, liposarcoma
- LIPSCOMB, ALYS.** See **VAN MIDDLESWORTH, L.**
- LIU, CHI KONG.** See **ELDRIDGE, FREDERIC L.**
- LIVER**
- See also Portal Vein
- abdominal aortography for roentgen demonstration of liver and spleen (ab), Leo G. Rigler and Paul C. Offelt, Aug., 306
- effect of total-body x-irradiation on hepatic and renal function in albino rats (ab), Kee-Chang Huang et al, Aug., 322
- estimation of liver function by cholangiography (ab), Eric Samuel et al, Nov., 811
- roentgen examination (ed), Leo G. Rigler, Dec., 936
- uptake of radioactive iodine in thyroid of patients with impaired liver function (ab), Richard Mueller et al, Sept., 485
- Lipids.** See Lipoids
- LLOYD-ROBERTS, G. C.:** Osteoarthritis of the hip. A study of the clinical pathology (ab), Dec., 955
- LOCKE, BEN Z.** See **SIEGAL, WILLIAM**
- LODIN, HERMAN.** See **GYLLENSWÄRD, ÅKE**
- LÖFFLER, W., and JACCARD, G.:** Chylothorax (chylotoe) with pseudo-miliary lesions in the lungs. Case report (ab), Sept., 464
- LÖFGREN, P. OLOV:** Renal tumour not demonstrable by urography but shown by renal angiography (ab), Aug., 311
- LOFSTROM, J. E., WEBSTER, J. E., and GURDJIAN, E. S.:** Angiography in the evaluation of intracranial trauma, Dec., 847
- LOIASIS**
- calcification (ab), Hor Williams, Aug., 312
- LOONEY, WILLIAM B.:** Late clinical changes following the internal deposition of radioactive materials (ab), Dec., 967
- LOOSE, K. E.:** Importance of serial aortography for demonstration of blood vessels in pelvis and kidney (ab), Sept., 480
- LOUGH, S. ALLAN:** Colloidal gold infusion unit (ab), Dec., 965
- LOVE, JESSHILL:** Coronal effects observed while rotating a film within an x-ray beam (ab), Aug., 316
- LOW-BEER, B. V. A.** See **HINMAN, FRANK, Jr.**
- LUCAS, ARTHUR C.** See **TROUT, E. DALE**
- LUCAS, P.** See **CRAWFORD, T.**
- LUDIN, H.:** Pancreas visualization by right lateral sagittal tomograms after combined retro- and intraperitoneal gas insufflation (ab), Nov., 813
- LUKAS, DANIEL S., ARAUJO, JORGE, and STEINBERG, ISRAEL:** Syndrome of patent ductus arteriosus with reversal of flow (ab), July, 128
- LUNGS**
- See also Arteries, pulmonary; Bronchi; Bronchiectasis; Pleura
- differential diagnosis of paramediastinal clouding of right upper lobe and superior mediastinal pleurisy (ab), P. Ch. Schmid, Sept., 464
- absence**
- agenesis (ab), Josef Klima, Nov., 799
- intralobar pulmonary sequestration; report of 3 cases, with 2 additional cases of agenesis of right upper and middle lobes in combination with anomalous systemic vessels (ab), Anthony Lalli et al, Oct., 626
- lobar agenesis (ab), Clifford F. Storey and Albert G. Marangoni, Sept., 462
- relationship of agenesis of lung to emphysema and cor pulmonale (ab), A. L. Warner et al, Dec., 946
- blood supply.** See also Embolism; Lungs, absence
- drainage of right pulmonary vein into inferior vena cava; report of case, with a radiologic analysis of principal types of anomalous venous return from lung (ab), Victor A. McKusick and Robert N. Cooley, Dec., 951
- pulmonary arterial oligemia in mitral stenosis as revealed on plain roentgenogram, Felix G. Fleischner and Elliot L. Sagall, Dec., 857
- pulmonary arteriovenous telangiectasis (ab), Fred N. Mitchell, Nov., 802
- total anomalous pulmonary venous drainage (ab), George Miller and Byron E. Pollock, Nov., 807
- varices (ab), A. Stecken, Nov., 799
- cancer.** See also Bronchi, cancer
- alveolar carcinoma (pulmonary adenomatosis) (ab), R. Pohl, Nov., 801
- carcinoma; 403 cases (ab), David P. Boyd et al, Aug., 291
- cavitation in metastatic pulmonary neoplasm (ab), Herbert Katzev and Hyman E. Bass, Dec., 947
- coexistent tuberculosis and carcinoma, Harry Hauser and Norman M. Glazer, Nov., 680
- Philadelphia Pulmonary Neoplasm Research Project; preliminary report (ab), Katharine R. Boucot et al, Nov., 802
- planigraphy in differential diagnosis of pulmonary nodule, with particular reference to notch sign of malignancy, Leo G. Rigler and E. Robert Heitzman, Nov., 692
- review of experiences with 1,457 cases of bronchogenic carcinoma (ab), Alton Ochsner et al, Dec., 946
- so-called alveolar-cell carcinoma (pulmonary adenomatosis) (ab), E. Langer and K. H. Willmann, Nov., 801
- spontaneous regression of pulmonary metastases of a chorio-epithelioma (ab), W. Rube, Sept., 464
- x-ray study of spontaneous pneumothorax due to cancer metastases to lungs (ab), Robert S. Sherman and Earl E. Brant, July, 126
- cavitation.** See Histoplasmosis; Lungs, cancer
- collapse**
- acute, transient middle lobe disease (ab), Eugene Rosenman, Nov., 800
- contribution of roentgenology to diagnosis of syndromes caused by bronchial stenosis following adenopathy (middle lobe syndrome and analogous syndromes) (ab), Luigi Pigorini and Gaetano Tricomi, Dec., 947
- differentiation of benign bronchiectasis and its relation to atelectasis (ab), H. Finke, Dec., 947
- cysts**
- cystic changes in histiocytosis (ab), Theodore E. Keats and Jackson P. Crane, Oct., 627
- intralobar pulmonary sequestration; report of 3 cases, with 2 additional cases of agenesis of right upper and middle lobes in combination with anomalous systemic vessels (ab), Anthony Lalli et al, Oct., 626
- diseases**
- correlation of radiological and pathological changes in some diseases (use of paper mounted sections) (ab), J. Gough, Nov., 798
- histoplasmosis. See Histoplasmosis
- pitfalls in roentgen diagnosis (ab), Philip J. Hodes, Aug., 291
- tuberculosis. See Tuberculosis, Pulmonary
- emphysema.** See Emphysema
- middle lobe disease.** See Lungs, collapse
- mycosis.** See Coccidioidomycosis; Histoplasmosis
- paragonimiasis.** See Paragonimiasis
- pathology**
- chylothorax (chylotoe) with pseudomiliary lesions in lungs; case (ab), W. Löffler and G. Jaccard, Sept., 464
- cryptococcosis with involvement of lungs and spine; case (ab), David Eisen et al, Nov., 802
- miliary pulmonary hemosiderosis in roentgenogram (ab), R. Haubrich and E. Versen, July, 126
- pulmonary appearances in polyarteritis nodosa (ab), Basil Strickland, Nov., 802
- pulmonary hemosiderosis in mitral stenosis (ab), H. E. Taylor and G. F. Strong, Nov., 805
- roentgenologic changes of lung associated with Isoniazid therapy in pulmonary tuberculosis (ab), David Salkin and J. A. Schwartz, July, 126
- scleroderma: pulmonary and skin studies before and after treatment with cortisone (ab), A. Salomon et al, Dec., 957
- roentgenography.** See also Bronchi, roentgenography
- bronchography in diagnosis of bronchogenic carcinoma in 2 patients with apparently normal chest films, Judah Zizmor, Dec., 868
- radiology of lung in severe mitral stenosis (ab), D. S. Short, Nov., 804
- tomography of bronchi and of hilar regions in right posterior oblique projection (ab), Alberto Maestri, Nov., 798
- sequestration.** See Lungs, cysts
- surgery**
- postoperative bronchopathies (ab), P. Mounier-Kuhn et al, Nov., 803
- tumors**
- adenomatosis. See Lungs, cancer
- alveolar-cell carcinoma. See Lungs, cancer
- angiocardigraphic findings (ab), Carlo Bompiani, Nov., 807
- tuberculoma: roentgen diagnostic and therapeutic considerations (ab), E. Kugel and M. Pöschl, Dec., 948
- vital capacity**
- thoracic volume and obesity (ab), R. Pohl and O. Scharff, Dec., 950
- LURÄ, A., FORNI, G., and BIAVATI, C.:** Adrenal images obtained with retroperitoneal insufflation and operative control (ab), Sept., 481
- LUSCHKA JOINTS.** See Spine
- LYMPH**
- lymph drainage from breast to axillary and parasternal lymph nodes studied with aid of colloidal Au¹⁹⁸ (ab), K. A. Hulthorn et al, Nov., 829
- study of lymph drainage of lower limb with use of colloidal radiogold (Au¹⁹⁸) (ab), K. A. Hulthorn et al, Dec., 964
- LYMPH NODES**
- cytochemical changes in lymph nodes and spleen of rats after total-body x-radiation (ab), G. Adolph Ackerman et al, July, 156
- inflammatory changes in bronchial glands in chronic bronchitis, demonstrated bronchographically (ab), Carl E. Gudbjerg and Gregers Thomsen, Aug., 293
- localization of radioactivity in urinary bladder and regional lymph nodes (ab), Harold F. Berg et al, July, 152
- lymph drainage from breast to axillary and parasternal lymph nodes studied with aid of colloidal Au¹⁹⁸ (ab), K. A. Hulthorn et al, Nov., 829

LYMPH NODES—cont.

- studies on transfer of lymph node cells. IV. Effects of x-irradiation of recipient rabbits on appearance of antibody after cell transfer (ab), T. N. Harris et al., Aug., 323
- time and site study for optimum lymph node concentration of radiogold following intrabronchial injection (ab), Harold F. Berg et al., Oct., 647
- cancer**
 - curability of regional metastases in cancer of uterine cervix (ab), John B. Graham and Ruth M. Graham, Dec., 959
 - radium treatment of squamous carcinoma in cervical nodes (ab), Alexander A. Charteris, Aug., 315
 - use of colloidal Au¹⁹⁸ for detection of lymph nodes in radical excision of breast (ab), K. A. Hultborn and L. I. Jonsson, Dec., 963
- tuberculosis**
 - combined treatment with roentgen rays and streptomycin in experimental tuberculous lymphadenitis in guinea-pigs (ab), C. Åhlander, July, 149
 - some serious complications: fatal hemoptysis, false aneurysm, occluded cisterna chyli and obstructive jaundice; review, with report of 5 cases (ab), Godfrey L. Gale, Sept., 462
- LYMPHADENITIS.** See Lymph Nodes
- LYMPHANGIOSARCOMA.** See Sarcoma, angiosarcoma
- LYMPHEDEMA.** See Arms
- LYMPHOCYTES**
 - cinemicrographic observations and theoretical considerations on reactions of lymphocytes to x-rays, Robert Schrek, Dec., 912
 - some effects of radiation on lymphoid cells (ab), D. O. Shiels, Aug., 320
- LYMPHOGRANULOMATOSIS.** See Hodgkin's Disease
- LYMPHOID TISSUE.** See Nasopharynx
- LYMPHOMA.** See Tumors, lymphoma
- LYNCH, KENNETH M., and McIVER, FORDE A.:** Pneumoconiosis from exposure to kaolin dust: kaolinosis (ab), Sept., 463

M

- McAFEE, C. ALAN.** See BRICKER, EUGENE M.
- McAULIFFE, THOMAS C.** See GLOVER, ROBERT P.
- McBURNIE, ROBERT P., KIRKLIN, JOHN W., and HOOD, ROBERT T.:** Asymptomatic bronchogenic carcinoma (ab), Nov., 801
- McCARTY, W. C., Jr., and LANE, F. W., Jr.:** Pitfalls of myelography, Nov., 663
- McCLENAHAN, JOHN.** See GLENN, FRANK
- McCLURE, C. C., Jr., CAROTHERS, E. L., and HAHN, P. F.:** Distribution and pathology resulting from the intracerebral and intraventricular injection of radioactive gold and silver coated radiogold colloids (ab), Nov., 830
- McCLURE, RICHARD F.:** Laminagraphy in acute maxillofacial injuries, Sept., 408
- McCORMICK, JAMES B., MILLES, GEORGE, JAFFE, BERTHA, and SEED, LINDON:** Tissue distribution of injected radioactive colloidal chromic phosphate (CrP⁵⁰O₄) (ab), July, 153
- McCORMICK, W. G.** See HALEY, THOMAS J.
- McCULLOH, EVE F.** See HALEY, THOMAS J.
- MACDONALD, R. IAN.** See FINLAY, J. M.
- McGRADE, EUGENE F.** See GONZALEZ, RUDOLPH M.
- MacINTYRE, WILLIAM J.** See STORAASLI, JOHN P.
- McIVER, FORDE A.** See LYNCH, KENNETH M.
- McKAY, J. M., and AITCHISON, J. D.:** The left lateral oesophagum in mitral valvular disease (ab), Nov., 804
- McKIBBEN, BYRON G., and LEE, SAMUEL:** Stenosis of the esophagus and stomach following the ingestion of corrosive substances (ab), Nov., 809
- McKUSICK, VICTOR A., and COOLEY, ROBERT N.:** Drainage of right pulmonary vein into inferior vena cava. Report of a case, with a radiologic analysis of the principal types of anomalous venous return from the lung (ab), Dec., 951
- McLAUGHLIN, WILLIAM L., and EHRLICH, MARGARETE:** Film badge dosimetry: how much fading occurs? (ab), Aug., 321
- McMILLAN, JAMES M.** See CARAVATI, CHARLES M.
- McNAUGHTON, ROBERT A.** See COMFORT, MANDRED W.
- McNICKLE, THOMAS F.** See LEAHY, WILLIAM V. C.
- MACRAE, T.** See NAYLOR, A.
- McWHIRTER TECHNIC.** See Breast, cancer
- MADDERN, SIDNEY C.** See TULLIS, JOHN L.
- MADELL, SAMUEL H., and GOLDEN, ROSS:** The ileum following colectomy, Oct., 539
- MADLENER METHOD.** See Fallopian Tubes
- MÄRTENSSON, G., and YDÉN, S.:** Technique for visualisation of the mental foramen. A case of an expanding soft tissue tumor in the mental foramen (ab), Aug., 291
- MAESTRI, ALBERTO:** Tomography of the bronchi and of the hilar regions in right posterior oblique projection (ab), Nov., 798
- MAGIDSON, O.** See WOOD, PAUL
- MAGNESIUM**
 - effect of magnesium on response of mice to large doses of whole-body irradiation, Henry C. Blount, Jr., Aug., 250
- MAINOLDI, FRANCO:** Protrusion of the acetabulum (ab), Nov., 817
- MALÉKI, A.:** One hundred seventeen cases examined by intravenous cholecystocholangiography (ab), Sept., 472
- MALLEUS.** See Ear
- MALLIS, NICHOLAS.** See SCHWARTZ, JACK W.
- MANDIBLE.** See Jaws
- MANKIEWICZ, EDITH, BLANK, F., and RUBIN, JACK H.:** Pulmonary histoplasmosis with cavitation (ab), Sept., 463
- MANN, BERTRAM, and DEASY, J. B.:** Talc pneumoconiosis in the textile industry (ab), Oct., 628
- MANNIX, E. P.** See DORNEY, E. R.
- MARBLE**
 - as radiation shield (ab), Marshall Brucer, Nov., 835
- MARBLE BONE DISEASE.** See Osteosclerosis fragilis
- MARINELLI, L. D.** See GUSTAFSON, P. F.
- MARKHAM, JAMES W., and OTENASEK, FRANK J.:** Neuromyelitis optica simulating spinal cord tumor. Report of a case, with a review of nine additional cases (ab), Oct., 626
- MÁRQUEZ, FERNANDO.** See TRABUCCO, ARMANDO
- MARANGONI, ALBERT G.** See STOREY, CLIFFORD F.
- MARSHAK, RICHARD H., WOLF, BERNARD S., and ADLERSBERG, DAVID:** Roentgen studies of the small intestine in sprue (ab), July, 131
- MARTIN, F. A., WEBSTER, J. E., and GURDJIAN, E. S.:** Significance of negative neurosurgical diagnostic studies (ab), Oct., 625
- MARTIN, JOHN E.** See LEMAK, LESLIE L.
- MARTIN, N. H.** See CRAWFORD, T.
- MARTIN, O.** See WHITEHOUSE, WALTER M.
- MASEL, H.** See BURT, L. IAN
- MASS SURVEYS.** See Tuberculosis, Pulmonary, mass roentgenologic surveys
- MASSÉL, THEODORE B.** See BORS, ERNEST
- MASTECTOMY.** See Breast, cancer
- MASTERS, FRANK.** See GEORGIADIS, NICHOLAS
- MATHEWSON, CARLETON, Jr.** See DOWNS, CHARLES R.
- MATTHEWS, LEROY W.** See GARRITY, RICHARD W.
- MATTHEWS, MARION.** See HOLLCROFT, JOANNE W.
- MAUTHE, HOWARD:** Accuracy of x-ray examination of the gallbladder (ab), July, 134
- and ZWICKY, GEORGE: Gastroduodenal intussusception, July, 86
- MAXILLA.** See Jaws
- MAXILLARY SINUS**
 - laminagraphy in acute maxillofacial injuries, Richard F. McClure, Sept., 408
- MAXON, F. C., Jr.** See GORHAM, L. W.
- MAYER, RAYMOND F.** See MOORE, THOMAS D.
- MAYFIELD, FRANK H.** See HUNTER, CURWOOD R.
- MEADORS, JASON L.** See RAYLE, ALBERT A., Jr.
- MECKEL'S DIVERTICULUM.** See Intestines, diverticula
- MECONIUM**
 - microcolon and meconium ileus (ab), G. Candardjis and F. Saegesser, Sept., 471
- MEDIASTINUM**
 - See also Pneumomediastinum
 - angiocardiology: a guide to mediastinal exploration (ab), Stanley M. Wyman, Aug., 295
 - cavography and mediastinal pathology (ab), Jarro Rosati, Nov., 807
 - differential diagnosis of paramediastinal clouding of right upper lobe and superior mediastinal pleurisy (ab), P. Ch. Schmid, Sept., 464
 - use of tomography for unexplainable infiltrations in upper mediastinum of infants (ab), H. W. Kirchhoff, Aug., 294
 - use of tomography in paramediastinal pleura following gas insufflation of mediastinum (ab), Graziano Pidone and Gaetano Cosentino, Nov., 804
- emphysema.** See Emphysema
- MEETINGS**
 - See also International Congress of Radiology; Radiological Society of North America; etc.
 - Eastern Conference of Radiologists, Aug., 284
- MEGEVAND, RENE P.** See PAUL, RAPHAEL N.
- MEHTA, M. M.:** Perigastric abscess. A case report with pre-operative roentgen diagnosis (ab), Dec., 952
- MEISEL, HERMAN J.:** Bilateral polyadenomatous kidneys: adenomatosis of the kidneys simulating polycystic disease (ab), Oct., 640
- MELAMINE**
 - cytochemical changes in lymph nodes and spleen of rats after total-body x-radiation (ab), G. Adolph Ackerman et al., July, 156
- MELANOMA.** See Tumors, melanoma
- MELE, M.** See TORSOLI, A.
- MELLINK, J. H.:** A 20 curie telecobalt unit (ab), Aug., 318
- MELTZER, PHILIP E.:** A study of lymphoid tissue of the nasopharynx (ab), July, 149
- MENDL, KARL, and TANNER, CLIVE H.:** Enterogenous cyst of the duodenum. Report of a case and review of the literature (ab), Oct., 635
- MENEGHINI, C.** See GASPARINI, S.
- MENESES HOYOS, JORGE, and ARAUJO, JOSÉ:** Interpretation of the low (cardiac) arch of cardiovascular roentgen silhouette in the oblique views (ab), Aug., 295
- MENINGES**
 - diagnosis of meningiomas within lateral ventricles of brain (ab), A. E. Wall, Aug., 291
 - experimental effects of radioactive colloidal gold in subarachnoid space; clinical application in treating brain tumors (ab), Fred W. L. Kerr et al., Sept., 487

- MENINGIOMA.** See Meninges
- MENINGOCELE**
—of intrathoracic development (ab), Ch. Gernez-Rieux and G. Lepaul, July, 127
- MENOPAUSE**
—postmenopausal vertebral osteoporosis (ab), A. Nurra and P. Pasquali, July, 139
—radium menopause or hysterectomy. Part I. The effects of the radiation menopause. A controlled study (ab), A. C. Turnbull, Dec., 960
- MERMANN, ALAN C., and DARGEON, HAROLD W.:** Management of certain nonlipid reticuloendothelioses (ab), Nov., 824
- MESCHAN, ISADORE, POOL, CHALMERS S., NETTLESHIP, ANDERSON, WINER, MELVIN, and ZEMAN, WOLFGANG:** The radiomicrography of the autopsy brain. I. The normal pattern, Nov., 770
- MESOTHELIOMA.** See Tumors, mesothelioma
- METABOLISM.** See Bones; Thyroid, hyperthyroidism
- METHIMAZOLE**
—metabolism of iodine in 2 goitrous cretins compared with that in 2 patients receiving methimazole (ab), John B. Stanbury et al, Nov., 828
- METHIONINE**
—use of radioactive sulfur labeled methionine in study of protein catabolism in burn patients (ab), T. G. Blocker, Jr., et al, Aug., 319
- MICROCOLON.** See Colon, abnormalities
- MICRORADIOGRAPHY.** See Radiomicrography
- MICTURITION.** See Urine and Urination
- MIDDLE LOBE SYNDROME.** See Lungs, collapse
- MILCH, HENRY:** Whip-lash injury of the lumbar neural arch (ab), Aug., 307
- MILKMAN'S SYNDROME.** See Ribs
- MILLER, EARL R., LINDSAY, STUART, and DAILEY, MORRIS E.:** Studies with radioiodine. V. Validity of histologic determination of I^{131} radiation changes in the thyroid gland, Sept., 384
—See HINMAN, FRANK, Jr.
- and SCOFIELD, NORMAN E.:** Studies with radioiodine. IV. Collimating cones for crystal counters, July, 96
- MILLER, FRANK L., and WALKER, RHEY:** The roentgen characteristics of pulmonary paragonimiasis, Aug., 231
- MILLER, GEORGE, and POLLOCK, BYRON E.:** Total anomalous pulmonary venous drainage (ab), Nov., 807
- MILLER, GEORGE A.** See GIANTURCO, CESARE
- MILLER, GERALD M.** See HINMAN, FRANK, Jr.
- MILLER, J. E.:** Roentgen examination of the upper gastrointestinal tract (ab), Sept., 467
- MILLER, WILLIAM, and KENNEDY, R. J.:** X-ray attenuation in lead, aluminum, and concrete in the range 275 to 525 kilovolts, Dec., 920
- MILLES, GEORGE.** See McCormick, James B.
- MILLS, WALDO H.** See BOGARDUS, GEORGE M.
- MINES AND MINERS**
—significant case of pneumoconiosis in a soft-coal worker (ab), Louis L. Friedman, Dec., 948
- MITCHELL, DOROTHY D.** See FORAKER, ALVAN G.
- MITCHELL, FRED N.:** Pulmonary arteriovenous telangiectasis (ab), Nov., 802
- MITCHELL, P. R.** See DAWSON, JOHN
- MITRAL VALVE**
—left lateral esophagram in mitral valvular disease (ab), J. M. McKay and J. D. Aitchison, Nov., 804
—miliary pulmonary hemosiderosis in roentgenogram (ab), R. Haubrich and E. Versen, July, 126
—pulmonary arterial oligemia in mitral stenosis as revealed on plain roentgenogram, Felix G. Fleischner and Elliot L. Sagall, Dec., 857
—pulmonary hemosiderosis in mitral stenosis (ab), H. E. Taylor and G. F. Strong, Nov., 805
—radioactive iodine therapy in euthyroid cardiac patient with previous mitral commissurotomy (ab), Frederick W. Pobors and Henry L. Jaffe, Dec., 962
—radiology of lung in severe stenosis (ab), D. S. Short, Nov., 804
- MIZBAH, GEOFFREY:** Hematoma of rectus sheath (ab), Oct., 639
- MOBERGER, GUNNAR:** Malignant transformation of squamous epithelium. A cytochemical study with special reference to cytoplasmic nucleic acids and proteins (ab), July, 156
- MOLLISON, P. L., and VALL, N.:** Use of the isotope ^{51}Cr as a label for red cells (ab), Nov., 831
- MOONEY, R. T.** See BRAESTRUP, C. B.
- MOORE, C. A., and DODSON, C. C.:** Urinary tract calculi in children. Renal and vesical calculi in an eight-month-old child (ab), Oct., 640
- MOORE, H. D.:** Treatment of acutely perforated peptic ulcers. Radiological diagnosis of site of perforation (ab), Nov., 810
- MOORE, JOHN R., and MORTON, H. S.:** Gastric carcinoma. A statistical review of 427 cases of carcinoma of the stomach from 1941 through 1950 (ab), Dec., 952
- MOORE, THOMAS D., and MAYER, RAYMOND F.:** Hypaque: an improved medium for excretory urography. A preliminary report of 210 cases (ab), Dec., 956
- MOORE, VINCENT, GAMBLE, DEAN, LIBBY, RAYMOND L., and GOODWIN, WILLARD E.:** Radioactive chromic phosphate in treatment of urological tumors (ab), Dec., 965
- MORALES, OLALLO, and ROMANUS, RAGNAR:** Urethrography in the male: the boundaries of the different urethral parts and detail studies of the urethral mucous membrane and its motility (ab), Nov., 822
- MORTON, H. S.** See MOORE, JOHN R.
- MOSES, CAMPBELL.** See KENT, EDWARD M.
- MOSHER, ROBERT E.** See CLARKE, NORMAN E.
- MOSIMAN ROSCOE S.** See RAY, ROBERT D.
- MOSS, IRWIN H.** See BAUER, ROBERT E.
- MOSSE, CARL E.:** Slipping of upper femoral epiphysis. Epiphysiolysis, epiphysiolisthesis, epiphyscal separation or fracture, epiphyscal coxa vara (ab), Aug., 307
- MOUNIER-KUHN, P., De ROUGEMONT, J., PERSILLON, A., and BRESSON, R.:** Postoperative bronchopathies (ab), Nov., 803
- MOUTH**
—See also Jaws; Teeth
—present-day indications for treatment of tumors of oral cavity, larynx and pharynx (ab), A. Zuppinger, Aug., 314
- MUCKLOW, ERIC H., and SMITH, OLIVER E.:** Dysphagia and unusual radiographic appearances associated with the variable relationships of the aorta and lower oesophagus (ab), Aug., 296
—See MUIR, IAN F. K.
- MUCUS**
—mucous colon, Maxwell H. Poppel, H. Adler, Harold G. Jacobson, J. Stein and L. R. Lawrence, July, 50
- MÜLLER, J. H.:** Treatment of carcinoma of the bladder with artificial radioactivity. Use of a liquid radioisotope in a balloon catheter, with special consideration of a Co^{60} solution (ab), July, 151
- MUELLER, RICHARD, BRAUSCH, CHARLES C., HIRSCH, EUGENE Z., BENUA, RICHARD S., and DOBYS, BROWN M.:** Uptake of radioactive iodine in the thyroid of patients with impaired liver function (ab), Sept., 485
- MÜLLER-MINY, HERIBERT:** Treatment of malignant melanomas (ab), Dec., 959
- MUIR, IAN F. K., MUCKLOW, ERIC H., and RAINS, ANTHONY J. H.:** Venography and the approach to varicose veins (ab), Sept., 467
- MUKHERJEE, B., and ADHIKARY, K. R.:** Mediastinal emphysema as a complication of therapeutic pneumoperitoneum (ab), Oct., 628
- MURPHY, FRANCIS D.** See MURPHY, TIMOTHY R.
- MURPHY, T. O.** See FELDER, D. A.
- MURPHY, TIMOTHY R., and MURPHY, FRANCIS D.:** The heart in acute glomerulonephritis (ab), July, 128
- MURTAGH, FREDERICK, STAUFFER, HERBERT M., and HARLEY, ROBISON D.:** A case of persistent carotid-basilar anastomosis associated with aneurysm of the homolateral middle cerebral artery manifested by oculomotor palsy (ab), Nov., 795
- MUSCETOLA, GIUSEPPE:** Anatomic-radiographic picture of giant osteomas in the paranasal sinuses (ab), Sept., 461
- MUSCLES**
—use of a short acting, muscle relaxant drug (succinylcholine chloride) in diagnostic urography; preliminary report (ab), D. R. Dick et al, Oct., 640
- abnormalities**
—arthrogryposis multiplex congenita, Harold G. Jacobson, Earle A. Herbert and Maxwell H. Poppel, July, 8
—surgical correction of eventration of diaphragm in patient with arthrogryposis; observation on cardiac manifestations of traction on diaphragm (ab), Philip Crastnopol, 81, Nov., 813
- MYCOSIS FUNGOIDES**
—some experiences with radioactive phosphorus in treatment (ab), F. E. Neal, Aug., 317
- MYELOGRAPHY.** See Spinal Canal Roentgenography
- MYELOMA.** See Bones, marrow
- MYLERAN**
—comparison of effects of radiation and radiomimetic chemicals on blood (ab), L. A. Elson, Nov., 832
- MYXEDEMA**
—clinical use of plasma butanol-extractable (thyroxin) I^{131} in diagnosis of hyperthyroidism and myxedema (ab), Alvin L. Schultz et al, July, 151
—renal function and I^{131} clearance in hyperthyroidism and myxedema (ab), Charles J. Hlad, Jr., and Neal S. Bricker, Oct., 647
- N**
- NADAS, ALEXANDER S.** See BRAUDO, J. LEONARD
- NAHON, JOSEPH R.:** Roentgenologic characteristics of the epicardial fat pad with a case report, Nov., 745
—and HAWKES, JOHN B.: Energy distribution in the thorax during multiple field and rotational therapy (ab), Sept., 483
- NAMIN, PIERRE:** Percutaneous vertebral angiography (ab), July, 125
- NASOLACRIMAL DUCT.** See Lacrimal Organs
- NASOPHARYNX**
—rhabdomyosarcoma, Elmer G. St. John and Zung-Pah Woo, Aug., 218
—study of lymphoid tissue (ab), Philip E. Meltzer, July, 140
- NASSIM, J. E.** See CRAWFORD, T.
- NAYLOR, A., HAPPEY, F., and MACRAE, T.:** The collagenous changes in the intervertebral disk with age and their effect on its elasticity. An x-ray crystallographic study (ab), July, 139

- NEAL, F. E.:** Some experiences with radioactive phosphorus in the treatment of mycosis fungoides (ab), Aug., 317
- NEALON, THOMAS, Jr.:** See **BOUCOT, KATHARINE R.**
- NEBEL, BERNARD R.:** Practical control measures for employees exposed to ionizing radiation hazards. Medical control (ab), Nov., 834
- NECK**
—spontaneous subluxation of atlantoaxial joint with inflammatory processes in neck (ab), E. Kotscher, Nov., 797
- NECROSIS**
—See also Abdomen, tumors; Brain
—avascular necrosis of phalanges of hands (Thiemann's disease) (ab), Ernest W. Shaw, Aug., 307
- NELSON, ARNE:** The protective effect of cysteamine on young mice exposed to roentgen rays (ab), Oct., 652
—See **CLEMEDSON, CARL-JOHAN**
- NELSON, CHARLES M., and WILLIAMS, GEORGE Z.:** The use of radioactive gold colloid in inoperable carcinoma of the bladder (ab), Dec., 964
- NELSON, T. Y., and REYE, DOUGLAS:** Tension emphysema: surgical emergency in infants (ab), Aug., 292
- NEPHRECTOMY.** See Kidneys, blood supply
- NEPHRITIS**
—heart in glomerulonephritis (ab), Timothy R. Murphy and Francis D. Murphy, July, 128
—nephrocalcinosis visible by x-ray associated with chronic glomerulonephritis (ab), Walter L. Arons et al., Dec., 957
- NEPHROCALCINOSIS.** See Kidneys, calcification
- NEPHROGRAPHY.** See Pyelography
- NERVES**
—See also Nervous System; Paralysis
—effect of high-intensity x-radiation on velocity of nerve conduction (ab), Herbert B. Gerstner et al., Nov., 832
- ROOTS**
—roentgen demonstration of cervical nerve root avulsion (ab), John E. Whiteather, Oct., 638
—syndrome of herniation of lower thoracic intervertebral disks with nerve root and spinal cord compression; presentation of 4 cases with a review of literature, methods of diagnosis and treatment (ab), Joseph A. Epstein, Sept., 477
- NERVOUS SYSTEM**
—See also Brain; Spinal Cord; Nerves; Sympathectomy
—neural conception of treatment of purulent skin diseases by roentgen irradiation (ab), C. Vojtek, Nov., 825
—significance of negative neurosurgical diagnostic studies (ab), F. A. Martin et al., Oct., 625
- NETTLESHIP, ANDERSON.** See **MESCHAN, ISADORE**
- NEUBAUER, EDWARD B. D.** See **BRAUDO, J. LEONARD**
- NEUKOMM, S.** See **JALLUT, O.**
- NEURITIS**
—neuritis optica simulating spinal cord tumor; report of case, with review of 9 additional cases, (ab), James W. Markham and Frank J. Otensack, Oct., 626
—osteoarthritis deformans of Luschka joints (ab), A. J. E. Cave et al., Nov., 816
- NEUROFIBROMATOSIS**
—neurofibromatosis and congenital unilateral pulsating and non-pulsating exophthalmos (ab), André J. Bruwer and Robert R. Kierland, Nov., 797
- NEUROMYELITIS OPTICA.** See Neuritis
- NEUTRONS**
—late effects of thermal neutron irradiation in mice (ab), A. C. Upton et al., Aug., 323
—production of cataracts in animals by x-rays and fast neutrons, P. J. Leinfelder, T. C. Evans and E. Riley, Sept., 433
- NEWELL, ROBERT R.** See **KRISS, JOSEPH P.**
- NEWTON, K. A.** See **NICHOLSON, J. P.**
- NICE, CHARLES M., Jr., and HALL, C. WILLIAM:** Relationship of the left atrium to the opacified esophagus in upright and recumbent positions, July, 61
- NICHOLSON, J. P., WILSON, C. W., and NEWTON, K. A.:** Distribution of radioiodine observed in thyroid disease by means of Geiger counters—its determination and significance (ab), Sept., 486
- NICHOLSON, J. P.** See **FERLAZZO, G.**
- NICKEL, ELDON.** See **HINMAN, FRANK, Jr.**
- NICKSON, JAMES J.** See **FRANCIS, KENNETH C.**
- NIELSEN, JENS, and JORGSHOLM, B.:** Indication for moving beam therapy (ab), July, 150
- NIEMETZ, DAVID, and WHARTON, GEORGE K.:** Benign gastric polyps (ab), Dec., 952
- NIESET, ROBERT T.** See **HIDALGO, JOHN U.**
- NIKNEJAD, ISMAIL.** See **AURELIUS, J. RICHARDS**
- NITROFURAZONE.** See Testes, cancer
- NITROGEN MUSTARD**
—comparison of effects of radiation and radiomimetic chemicals on blood (ab), L. A. Elson, Nov., 832
—cytochemical changes in lymph nodes and spleen of rats after total body x-radiation (ab), G. Adolph Ackerman et al., July, 156
- NORELL, HANS-GÖSTA:** Roentgenologic visualization of the extracapsular fat: its importance in the diagnosis of traumatic injuries to the elbow (ab), July, 139
- NORMAN, O.** See **BERGMAN, F.**
- NOSE**
—atrophy of auricular and nasal cartilages following administration of chorionic gonadotrophins in case of arthritis mutilans with sicca syndrome (ab), Fred B. Rogers and John Lansbury, Nov., 797
- NOSIE, WILLIAM A.:** Controlled transorbital leukotomy (ab), July, 126
- NOTCH SIGN.** See Lungs, cancer
- NUCLEINS**
—effects of antitumor drugs upon P^{32} incorporation into nucleic acids of mouse tumors (ab), Jack D. Davidson and Betty B. Freeman, Nov., 830
—malignant transformation of squamous epithelium: cytochemical study with special reference to cytoplasmic nucleic acids and proteins (ab), Gunnar Moberger, July, 156
- NUCLEUS PULPOSUS.** See Spine, intervertebral disks
- NURNBERGER, C. E.** See **VAN MIDDLESWORTH, L.**
- NURRA, A., and PASQUALI, P.:** Postmenopausal vertebral osteoporosis (ab), July, 139
- NYHAN, WILLIAM L.** See **SILVER, HENRY K.**
- O**
- OBESITY**
—thoracic volume and obesity (ab), R. Pohl and O. Scharff, Dec., 950
- OBITUARIES**
Hampton, Aubrey O., Dec., 940
Reiley, Wm. Edgar, Oct., 617
request from Necrology Committee, Oct., 614
Williams, Francis B., Aug., 284
- OBSTETRICS.** See Pelvis, measurement; Placenta; etc.
- OCCIPITAL BONE**
—encephalographic study of normal morphology of occipital horns (ab), Sergio Chiappa, July, 125
- OCCUPATIONAL DISEASES.** See Industry and Occupations
- OCHRONOSIS**
—two cases (ab), Hugh P. Smith and Hugh P. Smith, Jr., Nov., 815
- OCHSNER, ALTON, RAY, C. JACK, and ACREE, PAGE W.:** Cancer of the lung. A review of experiences with 1,457 cases of bronchogenic carcinoma (ab), Dec., 946
- O'CONNELL, D.:** Observations on the use of chlorpromazine hydrochloride in radiation sickness (ab), Nov., 834
- O'CONNOR, FRANCIS J., and RITVO, MAX.:** Diagnosis of hiatus hernia on plain roentgenograms of the thorax and abdomen (ab), Nov., 814
- O'CONOR, VINCENT J.** See **BULKLEY, GEORGE J.**
- ODEBLAD, ERIK:** Pin-hole autoradiography (ab), Dec., 958
- ODELL, RICHARD T., and KEY, J. ALBERT:** Lumbar disk syndrome caused by malignant tumors of bone (ab), Nov., 816
- ODÉN, SVEN:** Triurol in cerebral angiography (ab), Dec., 946
—See **LINDGREN, GUNNAR**
- ÖTVÖS, E.:** Unsolved problems in the x-ray diagnosis of peptic ulcer. The atropine test (ab), Oct., 634
- OHELA, KALERVÖ.** See **STANBURY, JOHN B.**
- OLD AGE**
—bone density measurements of osteoporosis in the aged, J. Gershon-Cohen, Harald Schraer and Nathan Blumberg, Sept., 416
—importance of radiology in geriatrics (arterial diseases) (ab), Juan José Quezada, Aug., 299
- OLFELT, PAUL C.** See **RIGLER, LEO G.**
- OLIGEMIA.** See Blood, volume
- OLIVER, R.** See **ELLIS, FRANK**
- OLSEN, ROBERT.** See **LAHR, T. N.**
- O'NEIL, THOMAS J. E.** See **G. OVER, ROBERT P.**
- OPPENHEIMER, MORTON J.** See **STAUFFER, HERBERT M.**
- ORBIT**
—pituitary and orbital roentgen therapy in hyperophthalmic type of Graves' disease (ab), Per Olof Gedda and Martin Lindgren, July, 148
- ORLOFF, THEODORE L.** See **COHN, EDWIN M.**
- ORNITHOSIS**
—as an occupational hazard, Bernard Rosen, Sept., 373
- ORTH, JOHN S.** See **GERSTNER, HERBERT B.**
- OSMOSIS.** See Erythrocytes
- OSTEITIS.** See Pubic Bone
- OSTEOARTHRITIS**
—See also Fingers and Toes; Hip
—osteoarthritis deformans of Luschka joints (ab), A. J. E. Cave et al., Nov., 816
- hypertrophic pulmonary**
—diagnostic significance (ab), Alfred Vogl et al., Nov., 814
- OSTEOCHONDRITIS**
—localized osteochondritis of lumbar spine (ab), Douglas W. Lamb, Sept., 478
- deformans juvenilis**
—roentgen examination of proximal femur end in children and adolescents: a standardized technic also suitable for determination of the collum, anteversion, and epiphyseal angles: a study of slipped epiphysis and coxa plana (ab), Lars Billing, July, 140
—vertebra plana (Calve's disease) due to eosinophilic granuloma (ab), Edward L. Compere et al., Aug., 307
- dissecans**
—familial osteochondritis dissecans (ab), M. Pickering Pick, Dec., 954
—in three members of one family (ab), T. B. Gardiner, Dec., 954
—of talus, W. L. DeGunder, Oct., 390
- OSTEOCHONDROMA.** See Tumors, osteochondroma
- OSTEOCHONDROPATHY.** See Shoulder

- OSTEOCHONDROSIS.** See Spine
OSTEOLYSIS. See Bones
OSTEOMA. See Tumors, osteoma
OSTEOMALACIA
 —in New York (ab), I. Snapper et al, Sept., 473
OSTEOMYELITIS
 See also Spine
 —in newborn (ab), C. M. C. Potter, Sept., 474
OSTEOPATHIA HYPEROSTOTICA. See Bones, diseases
OSTEOPETROSIS. See Osteosclerosis fragilis
OSTEOPOROSIS. See Bones, atrophy; Spine, diseases
OSTEOSCLEROSIS
 —associated with chronic renal failure (ab), T. Crawford et al, Nov., 814
fragilis
 —marble bone disease with brachydactylia (ab), L. Takáts and N. Henye, Nov., 818
 —metaphyseal dysplasia, epiphyseal dysplasia, diaphyseal dysplasia, and related conditions. I. Familial metaphyseal dysplasia and craniometaphyseal dysplasia; their relation to leontiasis ossea and osteopetrosis; disorders of "bone remodeling" (ab), W. P. U. Jackson et al, Oct., 636
OTENASEK, FRANK J. See **MARKHAM, JAMES W.**
OTTENBERG, DONALD J. See **BOUCOT, KATHARINE R.**
OVARY
 See also Arteries, ovarian
abnormalities
 —diagnostic transabdominal pneumoperitoneum in children (ab), Ralph H. Kunstader and Alex Tulsy, July, 142
irradiation
 —during hysterolapinography (ab), E. Barnett and D. K. Bewley, Nov., 819
tumors
 —radioiodine tests in case of struma ovarii (ab), John F. Foulkes and Russell Fraser, Aug., 317
OVERTON, ROBERT C., BOLTON, BILLY F., and USHER, FRANCIS C. Extrinsic deformities of the colon mimicking carcinoma. A report of three cases (ab), Sept., 471
OXYGEN
 —irradiation of skin tumors during pure oxygen inhalation (ab), K. A. Hultborn and A. Forsberg, Oct., 642
- P**
- PAATERO, YRJÖ V.** The principles of the construction and function of the stereo-pantomograph. A device for stereoscopic pantomography with a single exposure (ab), Dec., 958
PACK, GEORGE T., and PIERSON, JOHN C. Liposarcoma. A study of 105 cases (ab), Aug., 313
—and TABAH, EDWARD J. Collective review. Primary retroperitoneal tumors: a study of 120 cases (ab), Aug., 314
PALATE
 —treatment of malignant tumors of tonsillar region and soft palate (ab), P. Kinsalud et al, Nov., 826
PALLADINO, N. M. See **WARNER, A. L.**
PALMER, EDDY D. Retrograde intussusception at the gastrojejunal stoma: two cases and a bibliography (ab), Sept., 469
 Subacute erosive ("peptic") esophagitis. Clinical study of one hundred cases (ab), July, 128
PALMER, WALTER L. See **LEVIN, ERWIN**
PALSY. See Paralysis
PANCREAS
 —fat absorption test using iodized oil, with particular application as a screening test in diagnosis of fibrocystic disease of pancreas (ab), Frederic N. Silverman and Harry C. Shirkey, Dec., 954
 —gastric adenomyosis vs. aberrant pancreas, Christian V. Cimmino, July, 73
 —generalized pulmonary emphysema as isolated manifestation of early cystic fibrosis of pancreas, Theodore E. Keats, Aug., 223
 —visualization by right lateral sagittal tomograms after combined retro- and intraperitoneal gas insufflation (ab), H. Ludin, Nov., 813
cancer
 —dysphagia in carcinoma (ab), L. Langton and J. W. Laws, Aug., 304
PANCREATIC DUCTS
 —solitary calculus of duct of Wirsung (ab), Robert B. Johnson and Harvey W. Baker, Oct., 636
PANTOPAQUE (ethyl iodophenylundecylate). See Spinal Canal Roentgenography
PAPILLA OF VATER. See Vater's Ampulla
PAPILLOMA. See Tumors, papilloma
PARABIOSIS
 —studies on nature of immunity to *Trichinella spiralis* in parabiotic rats. VII. Immune response of "uninfected" twin one month after its mate received an immunizing dose of irradiated (x-ray) larvae (ab), Herman Zaiman et al, Nov., 833
PARAGONIMIASIS
 —chest x-ray findings and some clinical aspects in pulmonary paragonimiasis (ab), Sze-Piao Yang et al, Nov., 803
 —roentgen characteristics of pulmonary paragonimiasis, Frank L. Miller and Rhey Walker, Aug., 231
PARALYSIS
 See also Paraplegia
 —neuromuscular disorders of the urinary tract in children, R. Parker Allen, Sept., 325
 —persistent carotid-basilar anastomosis associated with aneurysm of homolateral middle cerebral artery manifested by oculomotor palsy; case (ab), Frederick Murtagh et al, Nov., 795
PARAMETRIUM. See Uterus, cancer
PARAPLEGIA
 —following translumbar aortography (ab), Saul Boyarsky, Aug., 298
 —renal changes as screened by routine excretory urography (ab), A. Estin Comarr, Aug., 311
 —venous occlusion of lower extremities in paraplegic patients (ab), Ernest Bors et al, Aug., 300
PARASITES. See Loiasis; Paragonimiasis
PARATHYROID
 —hyperparathyroidism due to adenoma; report of 6 cases and a review (ab), I. McLean Baird et al, July, 138
 —localization of adenoma by arteriography (ab), Sven I. Seldinger, Sept., 461
PARIS, LEONARD. Pneumatosis cystoides intestinalis in infancy (ab), Nov., 810
PARKER, H. M. Radiation protection in the atomic energy industry. A ten-year review, Dec. 903
PARKER JOSEPH. See **PAUL, RAPHAEL N.**
PARROTT, MARSHALL. See **HAMILTON, JOSEPH G.**
PASQUALLI, P. See **NURRA, A.**
PATERSON, EDITH. See **PATERSON, RALSTON**
PATERSON, RALSTON, and PATERSON, EDITH. Hodgkin's disease (ab), Oct., 645
PAUL, RAPHAEL N., MEGEVAND, RENE P., and PARKER, JOSEPH. Tetralogy of Fallot with left ventricular hypertrophy (ab), Oct., 629
PAYNE, FRANKLIN L. See **LEWIS, GEORGE C., Jr.**
PEGUIRON, L. See **JALLUT, O.**
PELVIMETRY. See Pelvis, measurement
PELVIS
 See also Uterus, cancer
 —importance of serial aortography for demonstration of blood vessels in pelvis and kidney (ab), K. E. Loose, Sept., 480
measurement
 —assessment of value of antenatal radiological pelvimetry based on 500 successive pelvimetric examinations (ab), G. W. Pimblett and T. G. E. White, Dec., 956
 —clinical applications of obstetric radiology (ab), R. L. Haas, Aug., 308
 —orthostereoradiography in obstetrics: precision method for cephalopelvimetry (ab), Teodoro Flores Covarrubias, Aug., 309
roentgenography
 —diagnostic transabdominal pneumoperitoneum in children (ab), Ralph H. Kunstader and Alex Tulsy, July, 142
PENDERGRASS, E. P., and EDEIKEN, JACK. Peritoneal mesothelioma. Case report (ab), July, 148
PENIS
 —radiotherapy in malignant disease of testicle and penis (ab), Robert Cox, Oct., 645
PEPTIC ULCER
 —duodenorenal fistula; complication of peptic ulceration (ab), Francis E. Stock, Sept., 470
 —in children (ab), Leslie L. Lemak et al, Sept., 469
 —observations on diagnosis, treatment, and course of gastric ulcer: evaluation of gastric irradiation as an adjunct in medical treatment (ab), Erwin Levin et al, Oct., 646
 —primary peptic ulceration of jejunum (ab), S. Levitt and Eric G. Saint, Nov., 810
perforation
 —treatment of acutely perforated ulcers: radiologic diagnosis of site of perforation (ab), H. D. Moore, Nov., 810
roentgenography
 —unsolved problems in x-ray diagnosis: the atropine test (ab), E. Ötvös, Oct., 634
PERÄSALO, O., and KYLLÖNEN, K. E. J. A congenital subclavian arteriovenous fistula and a truncus brachiocephalicus totalis in the same patient (ab), Aug., 297
PERICARDIUM
 —relomic cyst simulating chronic pericardial effusion; case (ab), Francis S. Gerbasi, Aug., 294
 —roentgenologic characteristics of epicardial fat pad, with case report, Joseph R. Nahon, Nov., 745
PERITONEUM
 —mesothelioma; case (ab), E. P. Pendergrass and Jack Edeiken, July, 148
 —radioactive isotopes in carcinomatosis of serous body cavities (ab), Edward M. Kent et al, July, 151
 —surgical complications associated with intraperitoneal coloidal radiogold (ab), C. Jules Rominger, Aug., 319
PERKINS, BLANCHE, and BOGEN, EMIL. The Los Angeles x-ray survey film and record library, its past development, present activities and future possibilities (ab), Dec., 948
PERSILLON, A. See **MOUNIER-KUHN, P.**
PERTHES' DISEASE. See Osteochondritis deformans juvenilis
PETERS, HANNAH. Tolerance dose and permissible weekly exposure to x and gamma radiation (ab), Dec., 967
PETERSEN, OLAF. Radiation cancer. Report of 21 cases (ab), July, 155
PETERSON, CARRELL A. See **ROOT, GROSVENOR T.**

- PETERSON, DONALD H.** See **AURELIUS, J. RICHARDS**
- PETT, DONALD.** See **STONE, HERMAN**
- PETRIE, E. A.:** Aberrant right subclavian artery (ab), Oct., 631
- PEYTON, WILLIAM T.** See **FRENCH, LYLE A.**
- PHALANGES.** See **Fingers and Toes**
- PHARYNX**
See also **Nasopharynx**
cancer
—experiences at Zürich with radiotherapy of laryngeal and hypopharyngeal carcinoma, with reference to new international staging classification (ab), K. Schäfer, July, 146
—present-day indications for treatment of tumors of oral cavity, larynx and pharynx (ab), A. Zuppinger, Aug., 314
—radiation cancer (ab), Ronald W. Raven and V. B. Levison, Aug., 320
- PHEOCHROMOCYTOMA.** See **Tumors, pheochromocytoma**
- PHILLIPS, RALPH.** See **FRANCIS, KENNETH C.**
- PHLEBOGRAPHY.** See **Arms; Extremities**
- PHOSPHATASE**
—spleen adenosine triphosphatase activity in irradiated mice treated with spleen homogenate (ab), Willie W. Smith et al, Aug., 323
- PHOSPHORUS AND PHOSPHORUS COMPOUNDS**
—clinical picture of vitamin-D-resistant rickets (type "phosphate diabetes") (ab), W. Swoboda and W. Rupp, Sept., 474
—radioactive. See **Radioactivity**
- PHOTOFLUOROGRAPHY.** See **Cardiovascular System**
- PHOTOGRAPHY**
—Biological Photographic Association, July, 115
—photographic method for measuring the distribution of dosage from radium needles and plaques (ab), E. Tochilin, Dec., 961
- PHYSIOLOGY**
—physiological point of view (ed), Robert P. Barden, Aug., 281
- PIATT, ARNOLD D., and ERHARD, GERALD A.:** Lesions with chronic symptoms producing pyloric obstruction and gastric decompensation, Oct., 303
- PICK, M. PICKERING:** Familial osteochondritis dissecans (ab), Dec., 954
- PICKRELL, KENNETH.** See **GEORGIADIS, NICHOLAS**
- PIDONE, GRAZIANO, and COSENTINO, GAETANO:** Use of tomography in the paramediastinal pleura following gas insufflation of the mediastinum (ab), Nov., 804
- PIERSON, JOHN C.** See **PACK, GEORGE T.**
- PIGORINI, LUIGI, and TRICOMI, GAETANO:** Contribution of roentgenology to the diagnosis of syndromes caused by bronchial stenosis following adenopathy (middle lobe syndrome and analogous syndromes) (ab), Dec., 947
- PILLS**
—x-ray delineation of ingested enteric-coated substances (ab), Percy Barsky, Dec., 952
- PIMBLETT, G. W., and WHITE, T. G. E.:** An assessment of the value of antenatal radiological pelvimetry based on 500 successive pelvimetric examinations (ab), Dec., 956
- PITT-RIVERS, ROSALIND.** See **STANBURY, JOHN B.**
- PITUITARY BODY**
—hypophysectomy with radioactive chromic phosphate in treatment of cancer (ab), Sanford F. Rphenberg et al, Dec., 965
—mechanism of induction and characteristics of tumors induced by thyroidectomy (ab), Jacob Furth et al, Nov., 828
—microlocalized radiotherapy (ab), Carlos Santos, Nov., 823
—pituitary and adrenal influences on insulin-¹²⁵I degradation (ab), Neil J. Elgee and Robert H. Williams, Nov., 829
—pituitary and orbital roentgen therapy in hyperophthalmopathy type of Graves' disease (ab), Per Olof Gedda and Martin Lindgren, July, 148
- PITUITARY PREPARATIONS**
—effects of somatotrophic hormone (STH) and saline on mice exposed to total-body irradiation (ab), Mitchell W. Spellman et al, Nov., 833
- PLACENTA**
—histochemical studies of effect of irradiation (ab), Alvan G. Foraker et al, Nov., 832
—value of radiology in antepartum hemorrhage (ab), John Dawson and P. R. Mitchell, Sept., 480
- PLANIGRAPHY.** See **Body Section Roentgenography**
- PLANK, J. R.** See **KUKRAL, ALBERT J.**
- PLATOU, R. V.** See **SNYDER, C. HARRISON**
- PLATYBASIA.** See **Atlas and Axis**
- PLESCH, R., and SCHAAL, A.:** Near surface measurements of small gamma emitters by cadmium-sulfid crystal-probe (ab), Nov., 826
- PLEURA**
See also **Pleurisy**
—use of tomography in paramediastinal pleura following gas insufflation of mediastinum (ab), Graziano Pidone and Gaetano Cosentino, Nov., 804
- calcification**
—(ab), L. R. Sarin, Nov., 804
- effusions.** See also **Pleurisy**
—prophylaxis and palliation of malignant effusions with radioactive colloidal gold (ab), Irving I. Cowan and Frank G. Kariotis, Dec., 965
—radioactive isotopes in management of carcinomatosis of serous body cavities (ab), Edward M. Kent et al, July, 151
—study of radioactive phosphorus activities in effusions (ab), Robert E. Bauer et al, July, 151
—use of radioactive chromic phosphate (ab), Melville L. Jacobs, Aug., 317
- tumors**
—mesothelioma; 4 cases (ab), George M. Bogardus et al, Dec., 949
—roentgen aspects of mesothelioma, Nathaniel Finby and Israel Steinberg, Aug., 169
- PLEURISY**
—differential diagnosis of paramediastinal clouding of right upper lobe and superior mediastinal pleurisy (ab), P. Ch. Schmid, Sept., 464
—natural history of pleural effusion and orthopedic tuberculosis (ab), F. Harwood Stevenson, Dec., 949
—pleurisy and pleuritic residua, a quantitative consideration (ab), A. J. Rösl and K. Schaub, Nov., 803
- PLUNKETT, ROBERT E.** See **SIEGAL, WILLIAM**
- PLUTONIUM**
—comparison of hematologic effects of internally deposited radium and plutonium in dogs, Jean H. Dougherty, John Z. Bowers, Robert C. Bay and Panit Keyanonda, Aug., 252
- PNEUMATOSIS CYSTOIDES INTESTINALIS.** See **Intestines, cysts**
- PNEUMOCONIOSIS**
—benign tin oxide pneumoconiosis (ab), George E. Spencer and William C. Wycoff, Aug., 293
—classification of roentgenograms (ab), C. M. Fletcher, Nov., 800
—from exposure to kaolin dust: kaolinosis (ab), Kenneth M. Lynch and Forde A. Melver, Sept., 463
—grain dust pneumoconiosis (ab), J. R. Rüttner and A. Stöfer, Oct., 627
—significant case of pneumoconiosis in a soft-coal worker (ab), Louis L. Friedman, Dec., 948
—talc pneumoconiosis in textile industry (ab), Bertram Mann and J. B. Deasy, Oct., 628
—tuberculo-silicosis (ab), F. S. du Toit, Sept., 463
- PNEUMOGRAPHY**
See also **Cerebellum; Pneumomediastinum; Pneumoperitoneum**
—adrenal images obtained with retroperitoneal insufflation and operative control (ab), A. Lurà et al, Sept., 481
—gas insufflation through lumbar and presacral routes (ab), Seymour F. Wilhelm, July, 146
—pancreas visualization by right lateral sagittal tomograms after combined retro- and intraperitoneal gas insufflation (ab), H. Ludin, Nov., 813
- PNEUMOMEDIASTINUM**
—(ab), Juha Tapiovaara, Dec., 949
—in bronchial cancer (ab), A. Balme and A. Thévenet, July, 127
- PNEUMOPERITONEUM**
—diagnostic transabdominal pneumoperitoneum in children (ab), Ralph H. Kunstadter and Alex Tulskey, July, 142
—therapeutic. See **Tuberculosis, Pulmonary, surgical therapy**
- PNEUMOTHORAX**
—x-ray study of spontaneous pneumothorax due to cancer metastases to lungs (ab), Robert S. Sherman and Earl E. Brant, July, 126
- POBIRS, FREDERICK W., and JAFFE, HENRY L.:** Radioactive iodine therapy in euthyroid cardiac patient with previous mitral commissurotomy (ab), Dec., 962
- POCHIN, E. ERIC, CUNNINGHAM, R. M., and HILTON, GWEN:** Quantitative measurements of radioiodine retention in thyroid carcinoma (ab), Sept., 485
- PODOLSKY, MORTON L., and JESTER, ALBERT W.:** Distribution of air in the intestinal tract of infants during the first twelve hours as determined by serial roentgenograms (ab), Oct., 635
- PÖSCHL, M.** See **KUGEL, E.**
- POHL, R.:** Alveolar carcinoma of the lung (pulmonary adenomatosis) (ab), Nov., 801
—and **SCHARFF, O.:** Thoracic volume and obesity (ab), Dec., 950
- POLLOCK, BYRON E.** See **MILLER, GEORGE**
- POLLYCOVE, M.** See **HINE, G. J.**
- POLYARTERITIS NODOSA**
—pulmonary appearances (ab), Basil Strickland, Nov., 802
- POLYCYTHEMIA**
—treatment of polycythemia rubra vera with radioactive phosphorus (ab), D. Verel, Aug., 317
- POLYPI.** See **Tumors, polyp**
- POOL, CHALMERS S.** See **MESCHAN, ISADORE**
- POOLE-WILSON, D. S.:** Treatment of malignant tumours of the bladder by irradiation therapy (ab), Oct., 644
- POPPEL, MAXWELL H., ADLER, H., JACOBSON, HAROLD G., STEIN, J., and LAWRENCE, L. R.:** Mucous colon, July, 30
—See **JACOBSON, HAROLD G.**
- POWELL, J., and LEVASSEUR, J. CL.:** The osseous lacrimal pathway. The possibilities of its radiologic exploration (ab), Nov., 796
- PORTAL VEIN**
—venography in diagnosis of Cruveilhier-Baumgarten syndrome (ab), Charles M. Caravati and James M. MacMillan, Sept., 467
—visualization of gastric and lower esophageal veins by splenoportography in case of carcinoma of lesser curvature (ab), D. Catalano and S. Riccio, July, 130

- PORTMANN, U. V., DUNNE, E. F., and HAZARD, J. B.:** Manifestations of Hodgkin's disease of the gastrointestinal tract (ab), Sept., 468
- POSITION**
—in roentgenography. See Aneurysm, aortic; Body Section Roentgenography
- POTASSIUM**
—biologic decay rates and excretion of radiocesium, Cs^{134} , with evaluation as a tracer of potassium in dogs (ab), S. A. Threefoot et al, Dec., 967
- POTTER, C. M. C.:** Osteomyelitis in the new-born (ab), Sept., 474
- POTTS, IAN F.:** Further experiences in aortography (ab), Dec., 956
- POTT'S DISEASE.** See Spine, tuberculosis
- POWELL, M. L., and HILLER, H. G.:** Pulmonary coarctation (ab), Dec., 951
- POWELL, V. N.** See SEEDORF, E. E.
- PRESSURE**
—effect of pressure on healing of bone; experimental study (ab), Lee T. Ford and J. Albert Key, Sept., 475
- PRICHARD, MARJORIE, M. L.** See DANIEL, P. M.
- PROSTATE**
—cicatricial stenosis of vesical neck as a complication of retropubic prostatectomy (ab), Luis F. Ajamil and Mariano Valverde, Oct., 641
—intraprostatic injections of radioactive colloids. II. Distribution within the prostate and tissue changes following injection in dog (ab), George J. Bulkeley et al, July, 153
- CANCER**
—irradiation therapy (ab), J. D. Fergusson, Oct., 645
—radioactive chromic phosphate in treatment of urological tumors (ab), Vincent Moore et al, Dec., 965
—treatment of carcinoma with radioactive colloidal chromic phosphate (P^{42}); preliminary report (ab), Carl Ruschke and Henry L. Jaffe, July, 152
- PROTEINS**
See also Blood, proteins
—malignant transformation of squamous epithelium: cytochemical study with special reference to cytoplasmic nucleic acids and proteins (ab), Gunnar Moberger, July, 156
—use of radioactive sulfur labeled methionine in study of protein catabolism in burn patients (ab), T. G. Blocker, Jr., et al, Aug., 319
- PROWLER, JOSEPH R., and SMITH, ERNEST W.:** Dental bone changes occurring in sickle-cell diseases and abnormal hemoglobin traits, Nov., 762
- PUBIC BONE**
—complications of "osteitis pubis," including report of case of sequestrum formation giving rise to persistent purulent urethritis (ab), B. D. Stutter, July, 138
- PUGH, DAVID G.** See CRAIG, RICHARD M.
- See WILSON, THEODORE W.
- PULEO, GRACE L.** See CHAPMAN, WILLIAM P.
- PULMONARY VALVE**
—pulmonary valvular stenosis with intact ventricular septum: isolated valvular stenosis and valvular stenosis associated with interatrial shunt (ab), Sidney S. Sobin et al, Aug., 298
—simple pulmonary stenosis (ab), D. W. Barritt, Aug., 298
—surgery of infundibular pulmonic stenosis with intact ventricular septum (a type of "pure" pulmonic stenosis) (ab), Robert P. Glover et al, Sept., 465
- PUTNAM, TRACY J.** See ROTHENBERG, SANFORD F.
- PYELOGRAPHY**
—common hazards of x-ray diagnosis in urologic practice: their recognition and reduction (ab), R. S. Clayton et al, July, 155
—correlation between contrast excretion and arterial and intrapelvic pressures in urography: experimental study in rabbits (ab), N. P. G. Edling et al, Oct., 640
—Hypaque: an improved medium for excretory urography. Preliminary report of 210 cases (ab), Thomas D. Moore and Raymond F. Mayer, Dec., 956
—intravenous urography using mixtures of radiopaque agents (Neo-Iopax, Diodrast, Urokon), Benedict R. Harrow, Aug., 265
—renal angiography in cases of delayed excretion in intravenous urography (ab), Hans Idoburn, Sept., 480
—renal changes in paraplegia as screened by routine excretory urography (ab), A. Eatin Comarr, Aug., 311
—renal tumor not demonstrable by urography but shown by renal angiography (ab), F. Olov Löfgren, Aug., 311
—retrograde pyelography with hydrogen peroxide in contrast medium; preliminary report (ab), Paavo Klami, July, 143
—use of a short acting, muscle relaxant drug (succinylcholine chloride) in diagnostic urography; preliminary report (ab), D. R. Dick et al, Oct., 640
—venous pooled nephrograms: technic and results (ab), John H. Detar and James A. Harris, Sept., 481
- PYLORUS**
See also Stomach, mucosa
—adverse effects of belladonna alkaloids in benign pyloric obstruction: experimental study (ab), Philip Kramer, July, 180
—lesions with chronic symptoms producing pyloric obstruction and gastric decompensation, Arnold D. Piatt and Gerald A. Erhard, Oct., 503
—stenosis of esophagus and stomach following ingestion of corrosive substances (ab), Byron G. McKibben and Samuel Lee, Nov., 809
- Q**
- QUEZADA, JUAN J.:** The importance of radiology in geriatrics (ab), Aug., 299
- QUICK, RAYMOND S.** See BLOOR, ROBERT J.
- QUIMBY, EDITH H.:** Radioactive isotopes as aids in medical diagnosis (ab), Nov., 826
- R**
- RABWIN, MARCUS.** See FREEDMAN, EUGENE
- RACK, FRANK J., and GLAZER, NORMAN:** A suggestive x-ray sign of strangulation in intestinal obstruction (ab), July, 131
- RADIATIONS**
See also Atomic Bomb; Radioactivity; Radium; Radon; Roentgen Rays; Thorotrast
—recommendations of Seventh International Congress on units and protection, Nov., 787
—tolerance dose and permissible weekly exposure to x and gamma radiation (ab), Hannah Peters, Dec., 967
- EFFECTS**
—histologic effects of various types of ionizing radiation on normal and hyperplastic human thyroid glands (ab), Stuart Lindsay et al, Aug., 320
—of ionizing radiation on immunity (ab), William H. Hale and Richard D. Stoner, Aug., 321
—radium menopause or hysterectomy. Part I. The effects of the radiation menopause. A controlled study (ab), A. C. Turnbull, Dec., 960
—some effects of radiation on lymphoid cells (ab), D. O. Shiels, Aug., 320
- INJURIOUS EFFECTS**
—ill-effects of radiotherapy (of urinary tract) (ab), D. M. Wallace, Oct., 645
—pathogenesis and pathology of post-irradiation infection (ab), V. P. Bond et al, Aug., 321
—radiation cancer: 21 cases (ab), Olaf Petersen, July, 155
—susceptibility of irradiated animals to infection (ab), I. L. Shechmeister, Aug., 321
—treatment of post-irradiation infection (ab), Carolyn W. Hammond, Aug., 321
—treatment of radiation sickness with sulfhydryl compounds and its problems (ab), Heinz Heuwieser, Aug., 321
- PROTECTION AGAINST.** See also Atomic Bomb; Radioactivity, radiocobalt, Roentgen Rays, protection against
—administrative problems in radiation protection (ab), Irving R. Tabershaw and Saul J. Harris, Oct., 632
—film badge dosimetry: how much fading occurs? (ab), William L. McLaughlin and Margaret Ehrlich, Aug., 321
—marble as radiation shield (ab), Marshall Brucer, Nov., 835
—protection measures in a university, Titus C. Evans, Dec., 875
—radiation hazard evaluation and control in hospitals, G. Ferlazzo, T. Nicholson, A. Jacobson and M. Bushman, Dec., 892
—recommendations of Seventh International Congress on units and protection, Nov., 787
- RADIOACTIVITY**
See also Atomic Bomb; Radiations; Radium; Thorotrast
—Geiger counter probe for diagnosis and localization of posterior intraocular tumors (ab), Charles I. Thomas et al, July, 154
—grants-in-aid for radioisotope training, Aug., 284
—near surface measurements of small gamma emitters by cadmium-sulfid crystal-probe (ab), R. Plesch and A. Schaaf, Nov., 826
—Oak Ridge Institute of Nuclear Studies: special courses, Oct., 614
—pinhole autoradiography (ab), Erik Odeblad, Dec., 958
—practical control measures for employees exposed to ionizing radiation hazards. Medical control (ab), Bernard R. Nebel, Nov., 834
—radioactive isotopes as aids in medical diagnosis (ab), Edith H. Quimby, Nov., 826
—radiotracer studies on bone, cementum, dentin, and enamel of Rhesus monkeys (ab), Reidar F. Sognnaes et al, Dec., 965
—scintillation counting for multiple tracer studies (ab), G. J. Hine et al, Dec., 966
—simplified apparatus for brain tumor surveys (ab), Herbert C. Allen, Jr., and J. R. Risser, Nov., 827
—suggested procedure for performance of autopsies on radioactive cadavers (ab), Russell F. Cowing and Egilda DeAmicis, Aug., 319
- RADIOACTIVE CHROMIC PHOSPHATE.** See Radioactivity, radiophosphorus
- RADIOASTATINE**
—accumulation and destructive action of astatine²¹¹ (EKA-iodine) in thyroid gland of rats and monkeys (ab), Joseph G. Hamilton et al, Aug., 320
—studies on thyroidal uptake of astatine in rat (ab), C. J. Shellabarger and John T. Godwin, Aug., 320
- RADIOCARBON**
—clinical research using compounds with labeled radioactive carbon and hydrogen as tracers (ab), George V. LeRoy, Dec., 966

RADIOACTIVITY, radiocarbon—cont.

- effect of x-rays and hormones on resorption rate of infected $\text{NaH}^{14}\text{CO}_3$ (ab), Arne G. Forsberg and George Hevesy, Dec., 968
- low-level counting, key to advances in radiocarbon dating (ab), J. Laurence Kulp, Oct., 648
- radiocesium**
 - biological decay rates and excretion of Cs^{134} , with evaluation as a tracer of potassium in dogs (ab), S. A. Threefoot et al., Dec., 967
- radiochloride**
 - studies on excretion of chloride by man with and without congestive heart failure, using long-life radiochloride, Cl^{36} (ab), C. T. Ray et al., Sept., 486
- radiochromium**. See also Radioactivity, radiophosphorus
 - use of isotope Cr^{51} as a label for red cells (ab), P. L. Mollison and N. Veall, Nov., 831
- radiocobalt**
 - absolute calibration of a cobalt-60 gamma-ray beam, S. Genna and J. S. Laughlin, Sept., 394
 - cobalt 60 protection design, C. B. Braestrup and R. T. Mooney, Dec., 884
 - hypothyroidism and thyroid hyperplasia in patients treated with cobalt (ab), Joseph P. Kriss et al., Nov., 829
 - intracavitary radiocobalt for bladder tumors; further experience (ab), Frank Hinman, Jr., et al., Dec., 963
 - response of burro to 100 r fractional whole-body gamma irradiation (ab), Thomas J. Haley et al., Dec., 968
 - stray radiation measurements around a cobalt 60 beam therapy installation (ab), Lillian E. Jacobson and Isabelle S. Knauer, Dec., 963
 - surface scintillation measurements in humans of uptake of parenterally administered radioactive vitamin B_{12} (ab), George B. Jerzy Glass et al., Dec., 966
 - three years' use of cobalt 60 unit (ab), K. W. Emery, Aug., 318
 - treatment of carcinoma of bladder with artificial radioactivity: use of liquid radioisotope in balloon catheter, with special consideration of Co^{60} solution (ab), J. H. Muller, July, 151
 - 20 curie telecobalt unit (ab), J. H. Mellink, Aug., 318
 - use of Co^{60} in nylon sutures in treatment of carcinoma of bladder; preliminary report (ab), Vincent Vermooten, Dec., 963
- radioiodine**
 - incorporation of radioactive L-cystine and L-methionine by leukemic leukocytes in vitro (ab), Austin S. Weisberger et al., Oct., 649
 - incorporation of radioactive L-cystine by normal and leukemic leukocytes in vivo (ab), Austin S. Weisberger and Bennett Levine, Oct., 649
- radiogold**
 - animal distribution of colloids of Au^{198} , P^{32} , and Y^{90} ; an improved method of tissue assay for radioactivity (ab), T. N. Lahr et al., Oct., 649
 - carcinoma of cervix: results obtained from irradiation of parametrium with radioactive colloidal gold (ab), Willard M. Allen et al., Oct., 647
 - colloidal gold infusion unit (ab), S. Allan Lough, Dec., 965
 - distribution and pathology resulting from intracerebral and intraventricular injection of radioactive gold and silver coated radiogold colloids (ab), C. C. McClure, Jr., et al., Nov., 830
 - distribution and radiation effects of intravenously administered colloidal Au^{198} in man (ab), Samuel W. Root et al., July, 153
 - experiences with use of colloidal gold in treatment of cancer (ab), H. Brownell Wheeler et al., Dec., 964
 - experimental effects of colloidal gold in subarachnoid space; clinical application in treating brain tumors (ab), Fred W. L. Kerr et al., Sept., 487
 - for intracavitary treatment of carcinoma of cervix, Michel Ter-Pogossian and Alfred I. Sherman, Nov., 779
 - intraprostatic injections of radioactive colloids. II. Distribution within prostate and tissue changes following injection in dog (ab), George J. Bulkley et al., July, 153
 - localization of radioactivity in urinary bladder and regional lymph nodes (ab), Harold F. Berg et al., July, 152
 - new method of treatment of inoperable brain tumors by stereotaxic implantation of radioactive gold; preliminary report (ab), J. Talairach et al., Dec., 965
 - pathogenesis of intestinal ulcers following irradiation: effects of colostomy and adhesions (ab), Nathan B. Friedman, Nov., 831
 - prophylaxis and palliation of malignant effusions with colloidal gold (ab), Irving I. Cowan and Frank G. Karioris, Dec., 965
 - radioactive isotopes in management of carcinomatosis of serous body cavities (ab), Edward M. Kent et al., July, 151
 - study of lymph drainage of lower limb with use of Au^{198} (ab), K. A. Hultborn et al., Dec., 964
 - surgical complications associated with intraperitoneal colloidal radiogold (ab), C. Jules Rominger, Aug., 319
 - technic for evaluating effectiveness of localization of radioactive colloidal gold 198 after direct injection into tumors (ab), John U. Hidalgo et al., Aug., 318
 - time and site study for optimum lymph node concentration of radiogold following intrabronchial injection (ab), Harold F. Berg et al., Oct., 647
 - treatment of bladder with colloidal gold, Au^{198} (ab), Frank Ellis and R. Oliver, Nov., 830

- use of colloidal Au^{198} for detection of lymph nodes in radical excision of breast (ab), K. A. Hultborn and L. I. Jonsson, Dec., 963
- use of gold colloid in inoperable carcinoma of bladder (ab), Charles M. Nelson and George Z. Williams, Dec., 964
- radiohydrogen**
 - clinical research using compounds with labeled radioactive carbon and hydrogen as tracers (ab), George V. LeRoy, Dec., 966
- radioiodine**. See also Thyroid
 - pituitary and adrenal influences on insulin- I^{131} degradation (ab), Neil J. Elgee and Robert H. Williams, Nov., 829
 - radioiodine tests in case of struma ovarii (ab), John F. Foulkes and Russell Fraser, Aug., 317
 - studies with radioiodine. IV. Collimating cones for crystal counters, Earl R. Miller and Norman E. Scofield, July, 96
 - treatment of multiple myeloma with radioactive iodine and radioactive iodinated serum albumin, Joseph P. Kriss, Howard R. Bierman, Sydney F. Thomas and Robert R. Newell, Aug., 241
- radioiron**
 - anemia and erythropoiesis in irradiated rat: an experimental study with particular reference to technics involving radioactive iron (ab), C. F. Baxter et al., Nov., 830
 - uptake of radioactive iron (Fe^{59}) by nucleated red cells in vitro (ab), L. G. Lajtha and H. D. Suit, Nov., 830
- radiomethionine**
 - incorporation of radioactive L-cystine and L-methionine by leukemic leukocytes in vitro (ab), Austin S. Weisberger et al., Oct., 649
- radiophosphorus**
 - animal distribution of colloids of Au^{198} , P^{32} , and Y^{90} ; an improved method of tissue assay for radioactivity (ab), T. N. Lahr et al., Oct., 649
 - differential radiophosphorus uptake of lens (ab), William H. Havener and Charles T. Knorr, Oct., 648
 - effects of antitumor drugs upon P^{32} incorporation into nucleic acids of mouse tumors (ab), Jack D. Davidson and Betty B. Freeman, Nov., 830
 - fate of injected radiophosphorus-labeled leukocytes (ab), William V. C. Leahy et al., Oct., 648
 - hypophysectomy with radioactive chromic phosphate in treatment of cancer (ab), Sanford F. Rothenberg et al., Dec., 965
 - in management of brain tumors (ab), Richard W. Garrity and LeRoy W. Matthews, Oct., 648
 - intraprostatic injections of radioactive colloids. II. Distribution within prostate and tissue changes following injection in dog (ab), George J. Bulkley et al., July, 153
 - radioactive chromic phosphate in treatment of urological tumors (ab), Vincent Moore et al., Dec., 965
 - relative biologic effects of x-rays and beta rays, William B. Seaman, Michel M. Ter-Pogossian and William B. Ittner, III, Aug., 260
 - research on utilization of radioactive PO_4Cr in colloidal solution for determination of circulating blood volume (ab), O. Jallut et al., July, 153
 - some experiences with radioactive phosphorus in treatment of mycosis fungoides (ab), F. E. Neal, Aug., 317
 - study of radioactive phosphorus activities in pleural effusions (ab), Robert E. Bauer et al., July, 151
 - tissue distribution of injected radioactive colloidal chromic phosphate ($\text{CrP}^{32}\text{O}_4$) (ab), James B. McCormick et al., July, 153
 - treatment of polycythemia rubra vera with radioactive phosphorus (ab), D. Verel, Aug., 317
 - treatment of prostatic carcinoma with radioactive colloidal chromic phosphate (P^{32}); preliminary report (ab), Carl Rusche and Henry L. Jaffe, July, 152
 - use of P^{32} as aid in diagnosis of intraocular neoplasms; further observations (ab), I. J. Eisenberg et al., Sept., 486
 - use of radioactive chromic phosphate in pleural effusions (ab), Melville L. Jacobs, Aug., 317
- radiostrontium**
 - studies of bone metabolism. I. A comparison of metabolism of strontium 90 in living and dead bone (ab), Robert D. Ray et al., Nov., 831
- radiosulfur**
 - use of radioactive sulfur labeled methionine in study of protein catabolism in burn patients (ab), T. G. Blocker, Jr., et al., Aug., 319
- radiothorium**
 - animal distribution of colloids of Au^{198} , P^{32} , and Y^{90} ; an improved method of tissue assay for radioactivity (ab), T. N. Lahr et al., Oct., 649
- vitamins**. See Radioactivity, radiocobalt
- RADIOAUTOGRAPHY**. See Radioactivity
- RADIOISOTOPES**. See Radioactivity
- RADIOLOGICAL SOCIETIES**
 - American Nuclear Society, Sept., 450
 - American Radium Society, July, 113
 - Arizona Radiological Society, Aug., 283
 - Arkansas Radiological Society, Sept., 450
 - Atlanta Radiological Society, Sept., 450
 - Baltimore City Medical Society, Radiologic Section, Aug., 283
 - Brockley Radiological Society, Nov., 787
 - Brooklyn Radiological Society, Sept., 450
 - Central Ohio Radiological Society, Oct., 614
 - Chicago Roentgen Society, July, 113
 - Cleveland Radiological Society, Oct., 614

RADIOLOGICAL SOCIETIES—cont.

- Connecticut State Medical Society, Section on Radiology, Aug., 283
- Connecticut Valley Radiologic Society, July, 114
- Florida Radiological Society, July, 114
- Indiana Roentgen Society, July, 114
- Kings County (New York) Radiological Society, Nov., 786
- Los Angeles Radiological Society, Nov., 786
- Maine Radiological Society, Sept., 450
- Maryland Radiological Society, July, 114
- Memphis Roentgen Society, Nov., 786
- Minnesota Radiological Society, Nov., 786
- Montana Radiological Society, Dec., 939
- New England Roentgen Ray Society, Aug., 283; Oct., 614
- New York Roentgen Society, Sept., 450
- North Florida Radiological Society, Nov., 786
- Ohio State Radiological Society, Sept., 450
- Oregon Radiological Society, Dec., 939
- Pennsylvania Radiological Society, Sept., 450
- Philadelphia Roentgen Ray Society, July, 114
- Pittsburgh Roentgen Society, Aug., 283
- Radiological Society of Greater Cincinnati, Sept., 450
- Radiological Society of Greater Kansas City, Nov., 786
- Radiological Society of Hawaii, Sept., 450
- Radiological Society of Louisiana, Aug., 283
- Radiological Society of New Jersey, July, 114
- Radiological Society of Southern California, Aug., 283
- Rocky Mountain Radiological Society, Midsummer Conference, July, 114
- secretaries and meeting dates, July, 118; Oct., 618
- Sociedad de Radiología, Cancerología y Física Médica del Uruguay, Aug., 283
- Sociedad Venezolana de Radiología, Aug., 283
- Società Italiana di Radiologia Médica, Nineteenth Congress, Oct., 615
- South Carolina Radiological Society, Aug., 283
- Southwestern Radiological Society, Nov., 786
- Tennessee Radiological Society, Aug., 283
- Tri-State Radiological Society, July, 114
- Upper Peninsula Radiological Society, Aug., 283
- West Virginia Radiological Society, Nov., 786
- Wisconsin Radiological Society, Dec., 939
- RADIOLOGICAL SOCIETY OF NORTH AMERICA**
- Crane, August W. 1898-1937 (annual historical lecture), Howar Doub, July, 3
- forty-first annual meeting: commercial exhibits, Oct., 609
- invitation to Annual Meeting (ed), Tom B. Bond, Sept., 439
- preliminary program, forty-first annual meeting, Chicago, Oct., 606
- refresher courses: postgraduate instruction, Sept., 440
- request from Necrology Committee, Oct., 614
- teaching or advertising (character of scientific exhibits) (ed), Robert P. Barden, Nov., 785
- RADIOLOGY AND RADIOLOGISTS**
- physiological point of view (ed), Robert P. Barden, Aug., 281
- radiologist and athletic injuries (ab), Everett F. Crutchlow, Oct., 638
- radiologist and chest surveys, T. J. Wachowski, July, 19
- residency training in radiology: an announcement, Aug., 284
- RADIOMICROGRAPHY**
- cinemicrographic observations and theoretical considerations on reactions of lymphocytes to x-rays, Robert Schrek, Dec., 912
- microtomography (ab), Knut Lindblom, Oct., 641
- of autopsy brain. 1. The normal pattern, Isadore Meschan, Chalmers S. Pool, Anderson Nettleship, Melvin Winer and Wolfgang Zeman, Nov., 770
- RADIOTHERAPY.** See Cancer, radiotherapy; Radioactivity; Radium; Roentgen Therapy; under diseases, organs, and regions
- RADIUM**
- See also Radiations; Radon; Uterus, cancer
- comparison of hematologic effects of internally deposited radium and plutonium in dogs, Jean H. Dougherty, John Z. Bowers, Robert C. Bay and Panit Keyanonda, Aug., 253
- K 9: a large 4 π gamma-ray detector (ab), M. A. Van Dilla et al, July, 154
- late clinical changes following internal deposition of radioactive materials (ab), William B. Looney, Dec., 907
- photographic method for measuring the distribution of dosage from radium needles and plaques (ab), E. Tochilin, Dec., 961
- RADON**
- radon released from concrete in radiant heating (ab), A. F. Gabrysh and F. J. Davis, Nov., 835
- spectrometric method for study of radon partition in radium-burdened animals, P. F. Gustafson and L. D. Marinelli, July, 90
- RAGNAR, ROMANUS.** See MORALES, OLALLO
- RAGNHULT, I.** See HULTBORN, K. A.
- RAI, K. M.** Malignant lymphoma: radiological aspects (ab), Dec., 959
- RAINES, SAMUEL L., and HURDLE, THOMAS G.** Tumors of the testis (ab), Dec., 961
- RAINS, ANTHONY J. H.** See MUIR, IAN F. K.
- RAJESKY, B., HEUSE, O., and ARAND, K.** Irradiation of white mice with large doses of x-ray (ab), Oct., 650
- RALL, J. E.** See HANBURY, E. M., Jr.
- RAVEN, RONALD W., and LEVISON, V. B.** Radiation cancer of the pharynx (ab), Aug., 320

- RAVITCH, MARK M.** Reduction of intussusception by barium enema (ab), Aug., 303
- RAY, C. JACK.** See OCHSNER, ALTON
- RAY, C. T., THREEFOOT, S. A., and BURCH, G. E.** Studies on the excretion of chloride by man with and without congestive heart failure, using long-life radiochloride, Cl^{36} (ab), Sept., 486
- See THREEFOOT, S. A.
- RAY, ROBERT D., LA VIOLETTE, DUANE, BUCKLEY, HAROLD D., and MOSIMAN, ROSCOE S.** Studies of bone metabolism. 1. A comparison of the metabolism of strontium⁹⁰ in living and dead bone (ab), Nov., 831
- REGAN, WILLIAM J.** See COLLIER, FREDERICK A.
- REILEY, WM. EDGAR** (obit), Oct., 617
- REISCH, D.** See BIERLING, G.
- RENCK, L.** See EDLING, N. P. G.
- RESEARCH**
- grants-in-aid in cancer research, July, 114
- RESIDENTS**
- residency training in radiology: an announcement, Aug., 284
- The Resident Physician, a new medical journal, Oct., 615
- RESPIRATORY TRACT**
- See also Bronchi; Lungs; Nasopharynx; Pharynx; etc.
- perforations of respiratory and alimentary tracts by metallic foreign bodies (ab), W. B. Finerman, Dec., 953
- RETICULOENDOTHELIAL SYSTEM**
- cystic changes of lungs in histiocytosis (ab), Theodore E. Keats and Jackson F. Crane, Oct., 627
- management of certain nonlipid reticuloendothelioses (ab), Alan C. Mermann and Harold W. Dargatz, Nov., 824
- RETICULOENDOTHELIOSIS.** See Reticuloendothelial System
- RETICULOSARCOMA.** See Sarcoma, reticulosarcoma
- RETOTHEL SARCOMA.** See Sarcoma, reticulosarcoma
- RETROPERITONEAL INSUFFLATION.** See Pneumography
- RETROPERITONEUM.** See Abdomen, tumors
- REYE, DOUGLAS.** See NELSON, T. Y.
- REYE, R. D. K.** See SCHREIBER, M. SOFER
- RHABDOMYOSARCOMA.** See Sarcoma, myosarcoma
- RHODE ISLAND MEDICAL SOCIETY,** Caleb Fiske prize, Nov., 787
- RIBS**
- thoracic outlet syndrome: case associated with short "first" rib, aneurysm of subclavian artery and occlusion of brachial artery (ab), J. K. E. Fraser and A. J. Barnett, Sept., 476
- Milkman's pseudofractures following extraperiosteal Ivalon pack, Samuel L. Cohen, Oct., 587
- RICCIO, S.** See CATALANO, D.
- RICHARDSON, AUBREY D.** See BAUER, ROBERT E.
- RICHE, E. W.** Irradiation therapy in urology: the kidney (ab), Oct., 644
- RICHEY, EVERETT O.** See GERSTNER, HERBERT B.
- RICKETS**
- clinical picture of vitamin D-resistant rickets (type "phosphate diabetes") (ab), W. Swoboda and W. Rupp, Sept., 474
- RIEMENSCHNEIDER, EDWIN A.** Gas in fetal circulation—a sign of fetal death. Case report (ab), Dec., 956
- and ECKER, ARTHUR: Venographic clues to localization of intracranial masses (ab), Sept., 459
- RIES, JULIUS.** See EYMER, HEINRICH
- RIGLER, LEO G., and HEITZMAN, E. ROBERT.** Planigraphy in the differential diagnosis of the pulmonary nodule, with particular reference to the notch sign of malignancy, Nov., 692
- and OLFELT, PAUL O.: Abdominal aortography for the roentgen demonstration of the liver and spleen (ab), Aug., 306
- See KUMP, WARREN L.
- RIKER, WILLIAM L.** Congenital diaphragmatic hernia (ab), July, 136
- RILEY, E.** See LEINFELDER, P. J.
- RILEY, G. M.** See HOLOUBEK, JOE
- RIPSTEIN, CHARLES B.** Perforation of the colon in ulcerative colitis (ab), Oct., 636
- RISSE, J. R.** See ALLEN, HERBERT C., Jr.
- RITTER, J. SIDNEY.** Aortography (ab), Nov., 806
- RITVO, MAX.** See O'CONNOR, FRANCIS J.
- ROACH, JOHN F., and HILLEBOE, HERMAN E.** Xero-radiography (ab), Aug., 312
- ROBBINS, LAURENCE L.** See SOUTTER, LAMAR
- ROBERT, F., and HOFFMANN, TH.** Hiatal anomalies and cardiac reflux. Defective development of the cardia and gastric fornix (ab), July, 129
- ROBINSON, J. MAURICE.** Detection of small lesions of the large bowel. Barium enema versus double contrast (ab), Sept., 470
- ROENTGEN RAYS**
- See also Betatron; Body-Section Roentgenography; Cine-radiography; Radiations; Roentgen Therapy
- x radiation from electronic power tubes (ab), S. C. Ballard, Aug., 324

ROENTGEN RAYS—cont.

- apparatus.** See also Roentgen Rays, stereoscopy
—apparatus for automatic introduction of radiopaque media in translumbar aortography (ab), Martin Langsam and Nathan D. Wilensky, Aug., 312
—convergent beam tube (ab), C. H. Bachman et al, Nov., 826
—improved x-ray stand, I. Klein, Sept., 420
—new 12 x 12-inch roll film magazine for rapid serial roentgenography, Israel Steinberg, William Dabiler and John A. Evans, Aug., 276
—radiolucent pneumatic compressor for mucosal studies, Isadore Katz, Aug., 271
- diagnosis.** See also Roentgen Rays, protection against; under diseases, organs and regions
—selenium compounds in contrast radiography; experimental study, Robert Shapiro, Sept., 429
—biological modification of effects. I. Reduced temperature (ab), Frederick M. Allen, Nov., 833
—cinemicrographic observations and theoretical considerations on reactions of lymphocytes to x-rays, Robert Schrek, Dec., 912
—combined effects of thermal burns and whole-body irradiation. II. Anemia (ab), A. K. Davis et al, Sept., 485
—combined effects of total-body irradiation and radiant energy thermal burns on osmotic and mechanical fragility of erythrocyte (ab), E. L. Alpen et al, Oct., 651
—comparison of effects of radiation and radiomimetic chemicals on blood (ab), L. A. Elson, Nov., 832
—control of radiation hemorrhage with splenic extracts (ab), J. Philip Savitsky, Nov., 834
—cytochemical changes in lymph nodes and spleen of rats after total-body radiation (ab), G. Adolph Ackerman et al, July, 156
—early radiation death in guinea-pigs (ab), K. C. Brace et al, Oct., 650
—effect of granulocyte count and litter on survival of irradiated mice (ab), Willie W. Smith et al, Aug., 323
—effect of hydroxylamine and irradiation on red cell destruction and formation and serum iron concentration (ab), Alfred Chanutin and Elizabeth L. Word, Oct., 652
—effect of irradiation on gastric secretion and the accompanying gross and histological changes in the "Shay" rat stomach (ab), Lawrence E. Detrick et al, Oct., 651
—effect of magnesium on response of mice to large doses of whole-body irradiation, Henry C. Blount, Jr., Aug., 250
—effect of single dose of x-rays on peripheral blood count of man (ab), W. M. Court Brown and John D. Abbott, Nov., 832
—effect of x-rays and hormones on resorption rate of injected NaHCO_3 (ab), Arne G. Forsberg and George Hevesy, Dec., 968
—effects of combined whole-body roentgen irradiation and high explosive blast injury in mice (ab), Carl-Johan Clemenson and Arne Nelson, Dec., 968
—hemostasis in sympathetomized and adrenalectomized animals before and after total-body irradiation (ab), Alfred L. Copley and Paul L. Stefkó, Oct., 651
—histochemical studies of effect of irradiation of placenta (ab), Alvan G. Foraker et al, Nov., 832
—inhibition of acute x-ray damage by cortisone (ab), L. E. Houghton et al, Oct., 652
—irradiation of white mice with large doses of x-ray (ab), B. Rajewsky et al, Oct., 650
—lack of effect of adrenalectomy on tumor regression following irradiation (ab), Joanne W. Hollcroft and Marion Matthews, Aug., 322
—late effects of thermal neutron irradiation in mice (ab), A. C. Upton et al, Aug., 323
—of high-intensity radiation on velocity of nerve conduction (ab), Herbert B. Gerstner et al, Nov., 832
—of total-body irradiation on hepatic and renal function in albino rats (ab), Kee-Chang Huang et al, Aug., 322
—of total-body irradiation on serum electrolyte levels and electrocardiograms of golden hamster (ab), George P. Fulton and Frederick N. Sudak, Aug., 322
—of whole-body irradiation on lipids in liver, kidney, and spleen of fasted rats (ab), W. E. Cornatzer et al, Nov., 832
—pathogenesis of intestinal ulcers following irradiation: effects of colostomy and adhesions (ab), Nathan B. Friedman, Nov., 831
—pathology of total-body irradiation in monkey (ab), Hans G. Schlumberger and Jacinto J. Vazquez, Oct., 650
—physiologic and histochemical changes in connective tissue of rat induced by total-body irradiation (ab), A. C. Upton and W. D. Gude, July, 155
—problem of radioresistance in biology and medicine (ab), G. Schubert, Dec., 968
—production of cataracts in animals by x-rays and fast neutrons, P. J. Leinfelder, T. C. Evans and E. Riley, Sept., 433
—protective effect of cysteamine on young mice exposed to roentgen rays (ab), Arne Nelson, Oct., 652
—relative biologic effects of x-rays and beta rays, William B. Seaman, Michel M. Ter-Pogossian and William B. Ittner, III, Aug., 260
—spleen adenosine triphosphatase activity in irradiated mice treated with spleen homogenate (ab), Willie W. Smith et al, Aug., 323
—spleen desoxyribonucleic acid content as index of recovery in irradiated mice treated with spleen homogenate (ab), Leonard J. Cole and Marie Ellis, Sept., 488
—studies on nature of immunity to *Trichinella spiralis* in parabiotic rats. VII. Immune response of "uninfected" twin one month after its mate received an immunizing dose of irradiated larvae (ab), Herman Zaiman et al, Nov., 833
—studies on transfer of lymph node cells. IV. Effects of x-irradiation of recipient rabbits on appearance of antibody after cell transfer (ab), T. N. Harris et al, Aug., 323
—study of effect of high temperature by hot baths, short waves and ultrasonics on cancer tissue and biological principles of combined x-ray-ultrasonics therapy of superficial tumors (ab), Karlheinz Woelber, Sept., 488
—study of local reaction on skin of mice, with special reference to vascular effects (ab), Finn Devik, Oct., 650
- films.** See also Film Badges
—coronal effects observed while rotating a film within an x-ray beam (ab), Jesshill Love, Aug., 316
- fluoroscopy.** See also Roentgen Rays, protection against
—adaptation of eyes for fluoroscopy (letter to editor), William G. Faraghan, Nov., 787
—practical image amplifier techniques; fluoroscopy, cinefluorography, spot-film radiography and use with closed circuit television, Herbert M. Stauffer, Morton J. Oppenheimer, George H. Stewart, III, and Archie S. Blackstone, Nov., 784
- injuries.** See also Radiations, injuries; effects; Roentgen Rays, effects; Roentgen Rays, protection against
—experimental studies. See Roentgen Rays, effects
—necrosis of brain following roentgen irradiation (ab), G. S. Dugger et al, Oct., 649
—observations on use of chlorpromazine hydrochloride in radiation sickness (ab), D. O'Connell, Nov., 834
—radiation cancer of pharynx (ab), Ronald W. Raven and V. B. Levison, Aug., 320
—radiation sickness: a study of its relation to adrenal cortical function and the absolute eosinophil count (ab), Elliott C. Lasser and K. Wilhelm Stenstrom, July, 154
- physics.** See also Roentgen Therapy; other headings under Roentgen Rays
—coronal effects observed while rotating a film within an x-ray beam (ab), Jesshill Love, Aug., 316
—specification of roentgen ray output and quality (ab), R. F. Farr, Dec., 958
—x-ray attenuation in lead, aluminum, and concrete in the range 275 to 525 kilovolts, William Miller and R. J. Kennedy, Dec., 920
- protection against.** See also Roentgen Rays, effects
—common hazards of x-ray diagnosis in urologic practice: their recognition and reduction (ab), R. S. Clayton et al, July, 155
—how safe is x-ray and fluoroscopy for patient and doctor? (ab), Norman W. Clein, July, 155
—law relating to work at x-ray installations in Hungary (ab), Josef Shanina, Nov., 834
—tolerance dose and permissible weekly exposure to x and gamma radiation (ab), Hannah Peters, Dec., 967
- stereoscopy.** See also Stomach, roentgenography
—principles of construction and function of the stereo-pan-tomograph: a device for stereoscopic pantomography with a single exposure (ab), Yrjö V. Paatero, Dec., 958
- ROENTGEN THERAPY**
—isodose curves for superficial therapy, E. Dale Trout, John P. Kelley, Arthur C. Lucas and Edward J. Furno, Nov., 703
—microlocalized radiotherapy (ab), Carlos Santos, Nov., 825
—new method for field localization (ab), G. Fuchs, Aug., 316
—radical surgery after intensive irradiation (ab), Harry L. Berman, Sept., 483
—radiotherapeutic test: an unreliable diagnostic procedure in intrathoracic mass lesions, Eugene R. Kutz, Sept., 378
—roentgen dose measurements on a radiation of very high intensity (ab), Bo Lindell, Sept., 483
—treatment planning (ab), Robert J. Bloor and Raymond S. Quick, Oct., 642
—x-ray dosage distribution in limited media (ab), L. G. Stephens-Newham and J. A. R. Cloutier, Oct., 642
- grid therapy.** See Cancer, radiotherapy
- rotational therapy.** See also Cancer, radiotherapy
—coronal effects observed while rotating a film within an x-ray beam (ab), Jesshill Love, Aug., 316
—energy distribution in thorax during multiple field and rotational therapy (ab), Joseph R. Nahon and John B. Hawkes, Sept., 483
—equipment and technique in precision rotation therapy (ab), S. Benner et al, Nov., 825
- RÖSLI, A. J., and SCHAUB, K.: Pleurisy and pleuritic residua, a quantitative consideration (ab), Nov., 803**
- ROGERS, FRED B., and LANSBURY, JOHN: Atrophy of auricular and nasal cartilages following administration of chorionic gonadotrophins in a case of arthritis mutilans with the sicca syndrome (ab), Nov., 797**
- ROMINGER, C. JULES: Surgical complications associated with intraperitoneal colloidal radiogold (ab), Aug., 319**
- RONCHESI, FRANCESCO, and KERN, ARTHUR B.: Bone lesions in Kaposi's sarcoma (ab), July, 138**
- ROOT, GROSVENOR T., CHRISTENSEN, BURT H., and PETERSON, CARRELL A.: Intussusception: an eight year survey (ab), Dec., 952**
- ROOT, SAMUEL W., ANDREWS, GOULD A., KNISELEY, RALPH M., and TYOR, MALCOLM P.: The distribution and radiation effects of intravenously administered colloidal Au^{198} in man (ab), July, 153**

- ROSATI, JARRO:** Cavography and mediastinal pathology (ab), Nov., 807
- ROSE, THOMAS F.:** Volvulus of the caecum (ab), Sept., 471
- ROSEN, BERNARD:** Ornithosis as an occupational hazard, Sept., 373
- ROSENBERG, MILTON L.:** Hypercalcuria and metabolic bone disease (ab), Oct., 641
- ROSENMAN, EUGENE:** Acute, transient middle lobe disease (ab), Nov., 800
- ROSS, J. F. See HINE, G. J.**
- ROSSETTI, MARIO:** Deformity of the left hemidiaphragm from a retothelial sarcoma of the spleen (ab), July, 135
- ROTATION THERAPY.** See Cancer, radiotherapy; Roentgen Therapy
- ROTH, FRANKLIN E. See SPELLMAN, MITCHELL W.**
- ROTHENBERG, SANFORD F., JAFFE, HENRY L., PUTNAM, TRACY J., and SIMKIN, BENJAMIN:** Hypophysitency with radioactive chromic phosphate in treatment of cancer (ab), Dec., 905
- ROWE, CAROLINE W.:** A program for roentgen examination of hospital admissions (ab), Aug., 293
- ROWLANDS, B. C. See BAIRD, I. McLEAN**
- ROZIN, SAMUEL:** Diagnosis of tubointestinal and tubovesical fistulas by hysterosalpingography (ab), Oct., 639
- RUBEL, JUNE. See ZALMAN, HERMAN**
- RUBIN, JACK H. See MANKIEWICZ, EDITH**
- RUBIN, MITCHELL I. See JACKSON, W. P. U.**
- RUBINSTEIN, CHARLES:** Mass x-ray survey: city of Sydney (ab), Nov., 799
- RUDOLPH, ABRAHAM M. See BRAUDO, J.**
- RÜBE, W.:** Spontaneous regression of pulmonary metastases of a chorionepithelioma (ab), Sept., 464
- RÜTTNER, J. R., and STOFER, A.:** Grain dust pneumoconiosis (ab), Oct., 627
- RUGGIERO, GIOVANNI, and CASTELLANO, FRANCESCO:** The pneumographic aspect of the angiotreticulum (hemangioblastoma) of the cerebellum (ab), Oct., 625
- DAVID, MARCEL, and TALAIRACH, JEAN:** Encephalography in brain tumors. A review of 104 cases (ab), Nov., 795
- See TALAIRACH, J.**
- RUPP, W. See SWOBODA, W.**
- RURAL CONDITIONS**
- experience with large routine chest film in rural hospital (ab), J. W. Boyd, Aug., 293
- RUSCHE, CARL, and JAFFE, HENRY L.:** Treatment of prostatic carcinoma with radioactive colloidal chromic phosphate (P³²): a preliminary report (ab), July, 152
- RUST, JOHN H. See HALEY, THOMAS J.**
- S**
- SACRALIZATION.** See Spine, intervertebral disks
- SAEGESSER, F. See CANDARDJIS, G.**
- SAGALL, ELLIOT L. See FLEISCHNER, FELIX G.**
- SAINT, ERIC G. See LEVITT, S.**
- ST. JOHN, ELMER G., and WOO, ZUNG-PAH:** Rhabdomyosarcoma of the nasopharynx, Aug., 218
- SALIK, JULIAN O. See ABESHOUSE, BENJAMIN S.**
- SALINE**
- effects of somatotrophic hormone (STH) and saline on mice exposed to total-body irradiation (ab), Mitchell W. Spellman et al., Nov., 833
- SALKIN, DAVID, and SCHWARTZ, J. A.:** Roentgenologic changes of the lung associated with isoniazid therapy in pulmonary tuberculosis (ab), July, 126
- SALOMON, A., APEL, B., DOUGHERTY, E. F., HERSCHFUS, J. A., and SEGAL, M. S.:** Scleroderma. Pulmonary and skin studies before and after treatment with cortisone (ab), Dec., 957
- SAMUEL, ERIC, GLUCKMAN, JONATHAN, and BARLOW, JOHN:** Estimation of liver function by cholangiography (ab), Nov., 811
- SANCHEZ, GUILLERMO C. See INGELFINGER, FRANZ J.**
- SANDHAUS, SOL. See SCHULTZ, ALVIN L.**
- SANGSTER, A. J.:** Calcification in carcinoma of the rectum (ab), Aug., 304
- SANTOS, CARLOS:** Microlocalized radiotherapy (ab), Nov., 825
- SAPEIKA, N.:** Lead calcium EDTA (ab), July, 145
- Lead EDTA complex: a water-soluble contrast medium (ab), July, 145
- Lead EDTA complex: further radiographic studies (ab), July, 145
- SARCOIDOSIS**
- Boeck's sarcoid of stomach simulating linitis plastica; report of case and comparison with 12 recorded cases (ab), Howard D. Sirak, Oct., 635
- SARCOMA**
- See also under names of organs and regions
- angiosarcoma**
- lymphangiosarcoma in postmastectomy lymphedema; 5-year survival with irradiation treatment (ab), Harry W. Southwick and Danely P. Slaughter, Nov., 823
- Kaposi's**
- bone lesions (ab), Francesco Ronchese and Arthur B. Kern, July, 138
- Kaposi's disease; unusual case, James H. Grove, Aug., 236
- liposarcoma**
- study of 105 cases (ab), George T. Pack and John C. Pierson, Aug., 313
- myosarcoma**
- rhabdomyosarcoma of nasopharynx, Elmer G. St. John and Zung-Pah Woo, Aug., 218
- osteosarcoma**
- massive preoperative irradiation in treatment of osteogenic sarcoma in children; preliminary report (ab), Kenneth C. Francis et al., Sept., 482
- reticulosarcoma**
- deformity of left hemidiaphragm from retothelial sarcoma of spleen (ab), Mario Rossetti, July, 135
- primary reticulum-cell sarcoma of bone, with emphasis on roentgen aspects, Theodore W. Wilson and David G. Pugh, Sept., 343
- synovial.** See Synovial Membrane
- SARIN, L. R.:** Calcification of the pleura (ab), Nov., 804
- SARKES, L. A. See HINE, G. J.**
- SARTESCHI, G. See TORSOLI, A.**
- SASS, ROBERT E. See COLCOCK, BENTLEY P.**
- SAVA, MARCELLA. See FREEDMAN, EUGENE**
- SAVITSKY, J. PHILIP:** Control of radiation hemorrhage with splenic extracts (ab), Nov., 834
- SBRANA, E. See TORSOLI, A.**
- SCANLON, ROBERT L., and YOUNG, BARTON R.:** Roentgen diagnosis of gallbladder and biliary tract disease without cholecystography (ab), Aug., 304
- SCAPULOHUMERAL JOINT. See Shoulder**
- SCHAL, A. See PLESCH, R.**
- SCHAEFER, J. P.:** A case of carotid-basilar anastomosis, with multiple associated cerebrovascular anomalies (ab), Nov., 795
- SCHÄRER, K.:** Experiences at Zürich with radiotherapy of laryngeal and hypopharyngeal carcinoma, with reference to the new international staging classification (ab), July, 146
- SCHARFF, O. See POHL, R.**
- SCHATZKI, RICHARD. See GARY, JOHN E.**
- SCHAUB, K. See RÖSLI, A. J.**
- SCHINZ, H. R., and WIDERÖE, R.:** Is rotation therapy with the betatron of 15 to 31 mev energy advantageous (ab), July, 150
- SCHLUMBERGER, HANS G., and VAZQUEZ, JACINTO J.:** Pathology of total body irradiation in the monkey (ab), Oct., 650
- SCHMID, P. CH.:** Differential diagnosis of paramediastinal clouding of the right upper lobe and superior mediastinal pleurisy (ab), Sept., 464
- SCHOLER, JOHN F., and CODE, CHARLES F.:** Rate of absorption of water from stomach and small bowel of human beings (ab), Sept., 470
- SCHOLTE, P. J. L., KOK-v. ALPHEN, C. C., and COMBÉE, B.:** Treatment of the cornea with a new Lilliput roentgen tube (ab), Aug., 316
- SCHORR, S., HOCHMANN, A., and FRAENKEL, M.:** Phlebographic study of the swollen arm following radical mastectomy (ab), Aug., 300
- SCHRAER, HAROLD. See GERSHON-COHEN, JACOB**
- SCHREIBER, M. SOFER, and REYE, R. D. K.:** Posterior fossa cysts due to congenital atresia of the foramina of Luschka and Magendie (ab), Sept., 460
- SCHREK, ROBERT:** Cinemicrographic observations and theoretical considerations on the reactions of lymphocytes to x-rays, Dec., 912
- SCHUBERT, G.:** The problem of radioresistance in biology and medicine (ab), Dec., 908
- SCHUCH, R. L. See VAN DILLA, M. A.**
- SCHULTE, JOHN W. See HIMMAN, FRANK, Jr.**
- SCHULTZ, ALVIN L., SANDHAUS, SOL, DEMOREST, HOWARD L., and ZIEVE, LESLIE:** Clinical use of the plasma butanol-extractable (thyroxine) I¹³¹ in the diagnosis of hyperthyroidism and myxedema (ab), July, 151
- See ZIEVE, LESLIE**
- SCHULTZ, H. H. See GORHAM, L. W.**
- SCHUSTER, A. See WARNER, A. L.**
- SCHWARTZ, BENJAMIN:** Histoplasmosis of lungs (ab), Oct., 627
- SCHWARTZ, HENRY G. See KERR, FRED W. L.**
- SCHWARTZ, J. A. See SALKIN, DAVID**
- SCHWARTZ, JACK W., and MALLIS, NICHOLAS:** Teratoma testis: report of 100 consecutive cases (ab), July, 147
- SCHWARTZ, W. See WARNER, A. L.**
- SCINTILLATION COUNTER. See Counters**
- SCLERODERMA**
- pulmonary and skin studies before and after treatment with cortisone (ab), A. Salomon et al., Dec., 957
- roentgenologic findings in diffuse scleroderma (ab), H. Goetsch, Dec., 957
- SCOFIELD, NORMAN E. See MILLER, EARL R.**
- SCOTT, MICHAEL. See LIN, PAUL M.**
- SEAMAN, WILLIAM B., TER-POGOSSIAN, MICHEL M., and ITINER, WILLIAM B., III:** Relative biologic effects of x-rays and beta rays, Aug., 200
- See KERR, FRED W. L.**
- SEED, LINDON. See MCCORMICK, JAMES B.**
- SEEDORF, E. K., POWELL, W. N., and DYSART, D. N.:** A comparison of five gallbladder media (ab), Aug., 304
- SEELY, R. See SNAPPER, I.**
- SEGAL, M. S. See SALOMON, A.**
- SELDINGER, SVEN I.:** Localization of parathyroid adenomata by arteriography (ab), Sept., 461
- SELLA TURCICA**
- size by age and sex (ab), Lewis L. Haas, Sept., 460

SEMINAL VESICLES

- spermatocystography in patients with spinal cord injuries (ab), A. Estin Comarr and Ernest Bors, Nov., 822
- vaso-epididymography and vasoseminal vesiculography (ab), Benjamin S. Abeshouse et al. Sept., 481

SHAPIRO, HARRY H., and CONVERSE, JOHN M.: Cephalographic diagnosis in the surgical treatment of malformations of the face (ab), Oct., 626

SHAPIRO, ISRAEL. See **EISEN, DAVID**

SHAPIRO, ROBERT: An experimental study of zirconium compounds in contrast radiography, Sept., 429

—See **BATT, HAROLD D.**

SHAW, ERNEST W.: Avascular necrosis of the phalanges of the hands (Thiemann's disease) (ab), Aug., 307

SHAW, JAMES H. See **SOGNNAES, REIDAR F.**

"SHAY" RAT. See Roentgen Rays, effects

SHECHMEISTER, I. L.: Susceptibility of irradiated animals to infection (ab), Aug., 321

SHELINE, G. E. See **DAVIS, A. K.**

—See **STEINBACH, HOWARD L.**

SHELLABARGER, C. J., and GODWIN, JOHN T.: Studies on the thyroidal uptake of astatine in the rat (ab), Aug., 320

SHERMAN, ALFRED I. See **ALLEN, WILLARD M.**

—See **TER-POGOSSIAN, MICHEL**

SHERMAN, ROBERT S., and BRANT, EARL E.: An x-ray study of spontaneous pneumothorax due to cancer metastases to the lungs (ab), July, 126

—and **CAUMARTIN, HUGH:** Roentgen appearance of adamantinoma of the mandible, Sept., 361

—and **CHU, FLORENCE C. H.:** Carcinomatous invasion of the jaw bones roentgenographically considered, Oct., 581

SHIELDS, D. O.: Some effects of radiation on the lymphoid cells (ab), Aug., 320

SHIPP, JOSEPH C., CROWLEY, LEONARD V., and WIGH, RUSSELL: Aortic sinus aneurysm. Production of intracardiac calcification and pulmonary artery fistula (ab), Nov., 805

SHIRKEY, HARRY C. See **SILVERMAN, FREDERIC N.**

SHORT, D. S.: Radiology of the lung in severe mitral stenosis (ab), Nov., 804

SHORT WAVES. See Diathermy

SHOULDER

—acromial apophysitis, a rare osteochondropathy (ab), F.-K. Landgraf, Oct., 639

—radiotherapy of arthrosis, spondylitis, periarthitis humero-scapularis and epicondylitis (ab), P. Hess and K.-H. Bonmann, Nov., 825

SICCA SYNDROME. See Conjunctiva

SICKLE-CELLS. See Erythrocytes, elliptical

SIEBENS, A. A. See **FLYNN, J. E.**

SIEGAL, WILLIAM, PLUNKETT, ROBERT E., and LOCKE, BEN Z.: Case findings from routine chest roentgenograms. Mass surveys of communities versus general hospital admissions (ab), Nov., 799

SIGMOID

—study by special roentgenographic views (ab), Alice Ettinger and Milton Elkin, July, 132

—diverticula

—actinomycotic diverticuloma (ab), Harry S. Hoffman, July, 133

—sigmoidouterine fistula complicating diverticulitis: case (ab), M. Harlan Johnston and George M. Stubbs, Nov., 811

SILICONES

—application of silicones to roentgenology of colon: a pilot study, Theodore E. Keats and Robert M. Whitrock, Oct., 578

SILICOSIS. See Pneumoconiosis

SILINKOVA-MÁLKOVÁ, E. See **SOYKA, O.**

SILVER, HENRY K., and NYHAN, WILLIAM L.: A technique for roentgenographic examination of newborn, premature, or ill infants without removal from an incubator (ab), Oct., 641

SILVER, RICHARD A. See **CAMPBELL, JOHN A.**

SILVERMAN, FREDERIC N., and SHIRKEY, HARRY C.: A fat absorption test using iodized oil, with particular application as a screening test in the diagnosis of fibrocystic disease of the pancreas (ab), Dec., 954

SILVERMAN, M. S. See **BOND, V. P.**

SIMKIN, BENJAMIN. See **ROTHENBERG, SANFORD F.**

SIMONSON, CAROL. See **CORNATZER, W. E.**

SINTON, WILLIAM. See **CARROLL, ROBERT E.**

SINUSES, PARANASAL

—bronchiectasis—dextrocardia—sinusitis: a contribution to etiology of bronchiectasis (ab), Carl E. Gudbjerg, Oct., 628

—anatomic radiographic picture of giant osteomas (ab), Giuseppe Muscatola, Sept., 461

SIRAK, HOWARD D.: Boeck's sarcoid of the stomach simulating linitis plastica. Report of a case and comparison with twelve recorded cases (ab), Oct., 635

SISSONS, H. A. See **CAMERON, J. A. P.**

SJOSTEDT, S. See **BERGMAN, F.**

SKANSE, BENGT. See **ZIEVE, LESLIE**

SKIN

—Ehlers-Danlos syndrome with ectopic bone formation, Isadore Katz and Karl Steiner, Sept., 352

—malignant transformation of squamous epithelium: cytochemical study with special reference to cytoplasmic nucleic acids and proteins (ab), Gunnar Moberger, July, 156

—neural conception of treatment of purulent skin diseases by roentgen irradiation (ab), C. Vojtek, Nov., 825

—physiologic and histochemical changes in connective tissue of rat induced by total-body irradiation (ab), A. C. Upton and W. D. Gude, July, 155

—scleroderma: pulmonary and skin studies before and after treatment with cortisone (ab), A. Salomon et al., Dec., 957

—study of local roentgen reaction on skin of mice, with special reference to vascular effects (ab), Finn Devik, Oct., 650

cancer

—radiation cancer: 21 cases (ab), Olaf Petersen, July, 155

tumors. See also Tumors, angio

—irradiation of skin tumors during pure oxygen inhalation (ab), K. A. Hultborn and A. Forsberg, Oct., 642

SKJERVEN, ODD. See **HOL, RAGNAR**

SKLAROFF, DAVID M. See **COHN, EDWIN M.**

SKORNECK, ALAN B. See **GINSBURG, LEONARD B.**

SKULL. See Cranium

SLADE, HARRY W. See **HOPE, JOHN W.**

SLANINA, JOSEF: The law relating to work at x-ray installations in Hungary (ab), Nov., 834

SLAUGHTER, DANIEL P. See **SOUTHWICK, HARRY W.**

SLINGERLAND, D. WARD: Influence of various factors on the uptake of iodine by the thyroid (ab), Nov., 828

SMEDAL, MAGNUS I. See **BOYD, DAVID P.**

SMITH, ERNEST W. See **PROWLER, JOSEPH R.**

SMITH, G. EDWARD. See **GREER, MONTE A.**

SMITH, HUGH P., and SMITH, HUGH P., Jr.: Ochronosis: report of two cases (ab), Nov., 815

SMITH, HUGH P., Jr. See **SMITH, HUGH P.**

SMITH, J. J. See **HARRIS, T. N.**

SMITH, OLIVER E. See **MUCKLOW, ERIC H.**

SMITH, PAUL K. See **LEAHY, WILLIAM V. C.**

SMITH, PHILIP W., WILSON, CHARLES W., CREGG, HUGH A., and KLASSEN, KARL P.: Cardioangiography (ab), July, 127

—See **CREGG, H. A.**

SMITH, T. BURTON: Renal anomalies. A source of confusion in diagnosis of abdominal disease (ab), Aug., 310

SMITH, WILLIE W., ANDERSON, WILLIAM, Jr., and ASHWELL, GILBERT: Spleen adenosine triphosphatase activity in irradiated mice treated with spleen homogenate (ab), Aug., 323

—**GONSHERY, LEON, ALDERMAN, ILO, and CORNFELD, JEROME:** Effect of granulocyte count and litter on survival of irradiated mice (ab), Aug., 322

SMITHERS, D. W.: The future of rotation therapy. Rotational irradiation of patients with deep-seated tumors (ab), July, 149

SMULEWICZ, J.: Further report on the combination of diverticula in the gastrointestinal tract with hiatal hernia (ab), July, 130

SNAPPER, I., SEELY, R., FALK, S., and FEDER, I.: Osteomalacia in New York (ab), Sept., 473

SNIFFEN, RONALD C. See **SOUTTER, LAMAR**

SNYDER, C. C. See **BLOCKER, T. G., Jr.**

SNYDER, C. HARRISON, BOST, ROGER B., and PLATOU, R. V.: Hypertension in infancy, with anomalous renal artery. Diagnosis by renal arteriography, apparent cure after nephrectomy (ab), Nov., 808

SOANES, WARD A., and DODSON, CLAUDE C.: Adrenal response to irradiation on patients with testicular tumors (ab), Aug., 315

SOBIN, SIDNEY S., CARSON, MERL J., JOHNSON, JOHN L., and BAKER, CHARLES R.: Pulmonary valvular stenosis with intact ventricular septum: isolated valvular stenosis and valvular stenosis associated with interatrial shunt (ab), Aug., 298

SODIUM BICARBONATE

—examination of superior portion of stomach by insufflation (using sodium bicarbonate) and stereoscopy (ab), Giacomo Bianchi, Nov., 809

SOFT TISSUES. See Hand: Jaws

SOGNNAES, REIDAR F., SHAW, JAMES H., and BOG-ORCH, RITA: Radiotracer studies on bone, cementum, dentin and enamel of Rhesus monkeys (ab), Dec., 965

SOLIS, JORGE. See **COMFORT, MANDREW W.**

SOSMAN, M. C. See **ARONS, WALTER L.**

SOSMAN, MERRILL C., honored, Sept., 450

SOTELO-ORTIZ, FEDERICO: Chronic coccidioid synovitis of the knee joint (ab), Nov., 818

SOULE, EDWARD H. See **CRAIG, RICHARD M.**

SOUTHWICK, HARRY W., and SLAUGHTER, DANIEL P.: Lymphangiosarcoma in postmastectomy lymphedema. Five-year survival with irradiation treatment (ab), Nov., 823

SOUTTER, LAMAR, SNIFFEN, RONALD C., and ROBBINS, LAURENCE L.: A clinical survey of adenomas of the trachea and bronchus in a general hospital (ab), Aug., 292

SOYKA, O., SILINKOVA-MÁLKOVÁ, E., and BLÁZEK, O.: Rare case of the bony form of Hodgkin's lymphogranuloma (ab), Nov., 815

SPELLMAN, MITCHELL W., ROTH, FRANKLIN E., BLANK, LEO, and LILLEHEI, C. WALTON: Effects of somatotrophic hormone (STH) and saline on mice exposed to total-body irradiation (ab), Nov., 833

SPENCER, GEORGE E., and WYCOFF, WILLIAM C.: Benign tin oxide pneumoconiosis (ab), Aug., 293

SPENCER, ROWENA. See **LIND, JOHN**

SPENCER, WILLIAM A. See **KESHISHIAN, JOHN M.**

SPERMATOCYSTOGRAPHY. See Seminal Vesicles

SPINAL CANAL ROENTGENOGRAPHY

- See also Spine, intervertebral disks
- myelogram in avulsion of brachial plexus, Albert A. Rayle, Jr., Brit B. Gay, Jr., and Jason L. Meadors, July, 65
- myelographic demonstration of basilar artery (ab), Flora M. Brown and Ralph C. Aye, Nov., 795
- myelography to help localize traction lesions of brachial plexus (ab), I. M. Tarlov and Robert Day, July, 141
- necessity for water-soluble contrast media for lumbar myelography (ab), H. Koberg, Dec., 955
- Pantopaque pulmonary embolism: a complication of myelography (ab), Leonard B. Ginsburg and Alan B. Skorneck, Nov., 817
- pitfalls of myelography, W. C. MacCarty, Jr., and F. W. Lane, Jr., Nov., 663
- roentgen demonstration of cervical nerve root avulsion (ab), John E. Whiteleather, Oct., 638

SPINAL CORD

- spinal cord damage in abdominal aortography (ab), Ragnar Hol and Odd Skjerven, Aug., 299
- abnormalities**
- diastematomyelia (ab), Colin B. Holman et al, Dec., 955
- diastematomyelia: case diagnosed preoperatively (ab), William R. Chambers, Oct., 639
- compression**
- syndrome of herniation of lower thoracic intervertebral disks with nerve root and spinal cord compression: presentation of 4 cases with review of literature, methods of diagnosis and treatment (ab), Joseph A. Epstein, Sept., 477

tumors

- neuromyelitis optica simulating spinal cord tumor: report of case, with review of 9 additional cases (ab), James W. Markham and Frank J. Otenasek, Oct., 626

wounds and injuries

- spematocystography in patients with spinal cord injuries (ab), A. Estin Comarr and Ernest Bors, Nov., 822

SPINE

- See also Atlas and Axis
- dysphagia of transitory type produced by hypertrophic spurs on cervical vertebrae (ab), Hugh Stephens and William L. Janus, Aug., 306
- study of function of cervical spine in dorsal and ventral flexion (ab), D. Albers, Sept., 476
- subluxation and deformation of cervical apophyseal joints: a contribution to etiology of headache (ab), Ákos Kovács, Nov., 816

arthritis

- osteoarthritis deformans of Luschka joints (ab), A. J. E. Cave et al, Nov., 816
- radiotherapy of arthrosis, spondylosis, periarthritis humeroscapularis and epicondylitis (ab), P. Hess and K.-H. Bonmann, Nov., 825

diseases

- localized osteochondritis of lumbar spine (ab), Douglas W. Lamb, Sept., 478
- postmenopausal vertebral osteoporosis (ab), A. Nurra and P. Pasquali, July, 139
- osteochondrosis in cervical spine, Ragnar Steinert, Sept., 412
- vertebra plana (Calvé's disease) due to eosinophilic granuloma (ab), Edward L. Compere et al, Aug., 307

fractures

- whip-lash injury of lumbar neural arch (ab), Henry Milch, Aug., 307

intervertebral disks

- calcification of disks in children (ab), C. S. Walker, Sept., 477
- collagenous changes in disk with age and their effect on its elasticity: an x-ray crystallographic study (ab), A. Naylor et al, July, 139
- complete protrusion of calcified nucleus pulposus in thoracic spine, Case (ab), Rohan Williams, Sept., 478
- discography in evaluation of lumbar lesions, Jack Friedman and Meyer Z. Goldner, Nov., 653
- lumbar disk syndrome caused by malignant tumors of bone (ab), Richard T. Odell and J. Albert Key, Nov., 816
- radiolucency lines (so-called vacuum phenomenon) in lumbar disks (ab), H. J. Fiebelkorn, Sept., 477
- sacralization: an etiological factor in lumbar disk lesions and a cause of misleading focal signs (ab), John Andrew, Sept., 477
- syndrome of herniation of lower thoracic disks with nerve root and spinal cord compression: presentation of 4 cases with review of literature, methods of diagnosis and treatment (ab), Joseph A. Epstein, Sept., 477

osteomyelitis

- associated with urinary tract infections, Ted F. Leigh, Robert P. Kelly and H. Stephen Weens, Sept., 334

pathology

- cryptococcosis with involvement of lungs and spine: case (ab), David Eisen et al, Nov., 802

tuberculosis

- unusual bone regeneration in Pott's disease (ab), Harold H. Cohen, July, 139

tumors

- lumbar disk syndrome caused by malignant tumors of bone (ab), Richard T. Odell and J. Albert Key, Nov., 816
- osteochondroma of lumbar spine: case (ab), Husameddin Gokay and Paul C. Bucy, Nov., 816
- roentgen manifestations of epidural granulomas of spine: 10 cases (ab), John A. Campbell and Richard A. Silver, July, 141
- vertebra plana (Calvé's disease) due to eosinophilic granuloma (ab), Edward L. Compere et al, Aug., 307

SPITZ, EUGENE B. See HOPE, JOHN W.**SPLEEN**

- abdominal aortography for roentgen demonstration of liver and spleen (ab), Leo G. Rigler and Paul C. Offelt, Aug., 306
- control of radiation hemorrhage with splenic extracts (ab), J. Philip Savitsky, Nov., 834
- cytochemical changes in lymph nodes and spleen of rats after total-body x-radiation (ab), G. Adolph Ackerman et al, July, 136
- spleen adenosine triphosphatase activity in irradiated mice treated with spleen homogenate (ab), Willie W. Smith et al, Aug., 323
- spleen deoxyribonucleic acid content as index of recovery in x-radiated mice treated with spleen homogenate (ab), Leonard J. Cole and Marie Ellis, Sept., 488

lipids. See Lipoids**tumors**

- deformity of left hemidiaphragm from a retothelial sarcoma (ab), Mario Rossetti, July, 135
- malignant tumor diagnosed by lental arteriography (ab), Gunnar Edsman, Oct., 641

SPLENOPORTOGRAPHY. See Portal Vein

- SPRAFAK, JOSEPH L., AZAD, MONOUCHEHR, and BARONOFSKY, IVAN D.:** Fate of esophageal hiatus hernia: a clinical and experimental study (ab), July, 137
- SPROAT, HARRY F. See KELLSEY, DAVID C.**
- SPRUE. See Celiac Disease**

STAMPFLI, WENDEL P. See BISCHOFF, MARTIN E.

- STANBURY, JOHN B., OHELA, KALERVO, and PITT-RIVERS, ROSALIND:** The metabolism of iodine in 2 goitrous cretins compared with that in 2 patients receiving methimazole (ab), Nov., 828

STANG, L. G., Jr. See HANBURY, E. M., Jr.**STARK, RICHARD B. See CONWAY, HERBERT****STARR, PAUL. See STONE, HERMAN**

- STAUFFER, HERBERT M., OPPENHEIMER, MORTON J., STEWART, GEORGE H., III, and BLACKSTONE, ARCHIE W.:** Practical image amplifier techniques; fluoroscopy, cinefluorography, spot-film radiography and use with closed circuit television, Nov., 784

—See MURTAGH, FREDERICK

- STECHER, ROBERT M., and HAUSER, HARRY:** Traumatic Heberden's nodes. Osteoarthritis of the fingers due to injury (ab), July, 140

STECKEN, A.: Concerning varices of the lungs (ab), Nov., 799**STEFKO, PAUL L. See COPLEY, ALFRED L.****STEIN, J. See POPPEL, MAXWELL H.**

- STEINBACH, HOWARD L., KEATS, THEODORE E., and SHELINE, GLENN E.:** Roentgen appearance of the pulmonary veins in heart disease, Aug., 137

—See HINMAN, FRANK, Jr.

- STEINBERG, ISRAEL, DUBILIER, WILLIAM, and EVANS, JOHN A.:** New twelve by twelve-inch roll film magazine for rapid serial roentgenography, Aug., 276

—See DUBILIER, WILLIAM, Jr.**—See FINBY, NATHANIEL****—See LUKAS, DANIEL S.****STEINER, KARL. See KATZ, ISADORE****STEINERT, RAGNAR:** Osteochondrosis in the cervical spine, Sept., 412

- STENSTRÖM, K. WILHELM. See LASSER, ELLIOTT C.**

- STEPHENS, HUGH, and JANUS, WILLIAM L.:** Dysphagia of transitory type produced by hypertrophic spurs on cervical vertebrae (ab), Aug., 306

STEPHENS-NEWSHAM, L. G., and CLOUTIER, J. A. R.: X-ray dosage distribution in limited media (ab), Oct., 642**STEREO-PANTOMOGRAPH. See Roentgen Rays, stereoscopy****STERILIZATION. See Fallopian Tubes****STERNUM. See Bones, marrow**

- STEVENSON, F. HARWOOD:** The natural history of pleural effusion and orthopneic tuberculosis (ab), Dec., 949

STEWART, GEORGE H., III. See STAUFFER, HERBERT M.**STH. See Pituitary Preparations**

- STOCK, FRANCIS E.:** Duodenorenal fistula: a complication of peptic ulceration (ab), Sept., 470

- STODTMEISTER, R., and FLIEDNER, M. TH.:** On the pathogenesis of bone marrow injury in rats subjected to total irradiation with fast electrons (15-mev Siemens betatron) (ab), July, 156

STOFER, A. See RÜTTNER, J. R.

- STOLL, BASIL A., and BEETHAM, W. R.:** Unidigital clubbing, with report of a case (ab), Sept., 479

STOMACH**See also Pylorus**

- hiatal anomalies and cardiac reflux: defective development of cardiac and gastric fornix (ab), F. Robert and Th. Hoffmann, July, 129
- lesions with chronic symptoms producing pyloric obstruction and gastric decompensation, Arnold D. Piatt and Gerald A. Erhard, Oct., 503

- perigastric abscess: case report with preoperative roentgen diagnosis (ab), M. M. Mehta, Dec., 952

- rate of absorption of water from stomach and small bowel of human beings (ab), John F. Scholer and Charles F. Code, Sept., 470

calcification. See Stomach, cancer

- Boeck's sarcoid of stomach simulating linitis plastica: report of case and comparison with 12 recorded cases (ab), Howard D. Sirak, Oct., 635

STOMACH, cancer—cont.

- calcification within stomach wall in gastric malignancy; case report and review of literature (ab), Lawrence E. Batlan, Sept., 469
- carcinoid, Walter H. Camp, Nov., 753
- gastric carcinoma: statistical review of 427 cases of carcinoma from 1941 through 1950 (ab), John R. Moore and H. S. Morton, Dec., 952
- small gastric cancer (ab), Mandred W. Comfort et al., Aug., 301
- visualization of gastric and lower esophageal veins by splenopography in case of carcinoma of the lesser curvature (ab), D. Catalano and S. Riccio, July, 130

cardiospasm

- gastroesophageal vestibule, its normal function and its role in cardiospasm and gastroesophageal reflux (ab), Franz J. Ingelfinger et al., Aug., 301

motility

- insulin-induced hypermotility in roentgen examination of stomach and duodenum, Denis C. Adler, George Jacobson, Kenneth A. Heitmann and Derrell D. Watson, Oct., 530

mucosa

- differential diagnosis of benign prolapse (ab), Jacob Lichstein, Nov., 809
- ectopic gastric mucosa in congenital small bowel diverticulum: roentgen demonstration and report of case, Warren L. Kump, Joseph Jorgens, and Leo G. Rigler, July, 81
- neglect of gastroduodenal mucosa by clinicians and radiologists (ab), V. J. Kinsella, Sept., 468
- transpyloric prolapse (ab), Mario Cerati, Sept., 468

obstruction

- See Intussusception
- roentgenography. See also Stomach, surgery
- barium in hydrogen peroxide in esophageal and gastric diagnosis, Cesare Gianturco and George A. Miller, Oct., 569

- examination of superior portion of stomach by insufflation (using sodium bicarbonate) and stereoscopy (ab), Giacomo Bianchi, Nov., 809

secretion

- effect of x-irradiation on gastric secretion and the accompanying gross and histologic changes in the "Shay" rat stomach (ab), Lawrence E. Detrick et al., Oct., 651

surgery

- retrograde intussusception at gastrojejunal stoma: 2 cases and a bibliography (ab), Eddy D. Palmer, Sept., 469
- some radiological aspects of resected stomach (ab), B. Thummen, Sept., 469

tumors

- benign polyps (ab), David Niemetz and George K. Wharton, Dec., 952
- Boeck's sarcoid of stomach simulating linitis plastica: report of case and comparison with 12 recorded cases (ab), Howard D. Sirak, Oct., 635
- gastric adenomyosis vs. aberrant pancreas, Christian V. Cimmino, July, 73
- gastric lymphoma, Gordon J. Culver, Berten C. Bean, and David L. Berens, Oct., 518
- leiomyoma (ab), Herbert L. Abrams, Oct., 634
- ulcers. See Peptic Ulcer

volvulus

- gastric volvulus. Part I. (ab), Charles Gottlieb et al., Aug., 301
- gastric volvulus. Part II. Idiopathic gastric volvulus (ab), David Lefferts et al., Aug., 301
- gastric volvulus. Part III. Secondary gastric volvulus (ab), Samuel L. Beranbaum et al., Aug., 301

- STONE, HERMAN, CATZ, BORIS, PETIT, DONALD, and STARR, PAUL: Therapeutic studies in hyperthyroidism. Use of radioactive iodine (ab), July, 150

STONER, RICHARD D. See HALE, WILLIAM H.**STONE, JAMES M. See ZAIMAN, HERMAN**

- STORAASLI, JOHN P., MacINTYRE, WILLIAM J., FRIEDELL, HYMER L., and WEIGLE, KEITH E., Jr.: Evaluation of methods of measuring the accumulation of ¹³¹I by the thyroid gland, Oct., 489

—See THOMAS, CHARLES I.

- STOREY, CLIFFORD F., and MARRANGONI, ALBERT G.: Lobar agenesis of the lung (ab), Sept., 462

STRACHMAN, JEROME. See CARD, RICHARD Y.**STRATFORD, J. G. See DUGGER, G. S.****STREPTOMYCIN. See Lymph Nodes, tuberculosis**

- STRICKLAND, BASIL: Pulmonary appearances in polyarteritis nodosa (ab), Nov., 802

STRONG, G. F. See TAYLOR, H. E.**STRONTIUM, RADIOACTIVE. See Radioactivity****STRUMA OVARII. See Ovary, tumors****STUBBS, GEORGE M. See JOHNSTON, M. HARLAN**

- STUTTER, B. D.: Complications of "osteitis pubis." Including a report of a case of sequestrum formation giving rise to persistent purulent urethritis (ab), July, 138

SUBARACHNOID SPACE. See Meninges**SUCCINYLCHOLINE CHLORIDE**

- use of a short acting, muscle relaxant drug (succinylcholine chloride) in diagnostic urography; preliminary report (ab), D. R. Dick et al., Oct., 640

SUDAK, FREDERICK N. See FULTON, GEORGE P.**SUDECK'S SYNDROME. See Bones, atrophy**

- SUGAR, OSCAR, and BUCY, PAUL C.: Some complications of vertebral angiography (ab), Sept., 459

SUHLAND, LEIF G. See WEISBERGER, AUSTIN S.**SUIT, H. D. See LAJTHA, L. G.****SULFHYDRYL COMPOUNDS**

- treatment of radiation sickness with sulfhydryl compounds and its problems (ab), Heinz Heuwieser, Aug., 321

SULFIDES

- near surface measurement of small gamma emitters by cadmium-sulfid crystal-probe (ab), R. Plesch and A. Schaal, Nov., 826

SULFUR, RADIOACTIVE. See Radioactivity**SUPPOSITORIES**

- opaque vaginal suppository mistaken for bladder calculus (letter to editor), George E. Irwin, Jr., Nov., 788

SURGERY

- See also under diseases, organs, regions and operations
- radical surgery after intensive irradiation (ab), Harry L. Berman, Sept., 483

SUTTON, DAVID: Percutaneous angiography with special

- reference to peripheral vessels (ab), Nov., 808
- and TILLET, JOHN V.: Intravenous cholecystography and cholangiography: clinical trials with a new medium (Biligradin) (ab), Aug., 306

SVIEN, HENDRIK J. See HOLMAN, COLIN B.**SWAN, HENRY. See GOYETTE, EDWIN M.****SWITZER, ROBERT A. See FELD, HAROLD**

- SWOBODA, W., and RUPP, W.: The clinical picture of vitamin-D-resistant rickets (type "phosphate diabetes") (ab), Sept., 474

SYMPATHECTOMY

- hemostasis in sympathectomized and adrenalectomized animals before and after total-body x-irradiation (ab), Alfred L. Copley and Paul L. Stefo, Oct., 651

SYNSTOSIS. See Cranium, abnormalities**SYNOVIAL MEMBRANE**

- chronic coccidioid synovitis of knee joint (ab), Federico Sotelo-Ortiz, Nov., 818
- roentgenologic manifestations of sarcoma, Richard M. Craig, David G. Fugh, and Edward H. Soule, Dec., 837

SZENDROI, ZOLTAN. See GIMES, BELA**T****TABAH, EDWARD J. See PACK, GEORGE T.****TABERN, D. L. See LAHR, T. N.**

- TABERSHAW, IRVING R., and HARRIS, SAUL J.: Administrative problems in radiation protection (ab), Oct., 632

TAKÁTS, L., and HENYE, M.: Marble bone disease with

- brachydactylia (ab), Nov., 818

TALAIRACH, J., RUGGIERO, G., ABOULKER, J., and DAVID, M.: A new method of treatment of inoperable brain

- tumours by stereotaxic implantation of radioactive gold. A preliminary report (ab), Dec., 965

—See RUGGIERO, GIOVANNI**TALC**

- talc pneumoconiosis in textile industry (ab), Bertram Mann and J. B. Deasy, Oct., 628

TALOCALCANEAL BRIDGE. See Ankle**TALUS. See Ankle****TANNER, CLIVE H. See MENDEL, KARL**

- TAPIOVAARA, JUHA: The pneumomediastinum (ab), Dec., 949

TARLOV, I. M., and DAY, ROBERT: Myelography to help

- localize traction lesions of the brachial plexus (ab), July, 141

TARSUS

- bone anomalies of tarsus in relation to "peroneal spastic flatfoot" (ab), E. A. Jack, Sept., 479

TAYLOR, H. E., and STRONG, G. F.: Pulmonary hemosidero-

- sis in mitral stenosis (ab), Nov., 805

TAYLOR, THOMAS L. See DUBILIER, WILLIAM, Jr.**TEACHING. See Education****TEETH**

- dental bone changes occurring in sickle-cell diseases and abnormal hemoglobin traits, Joseph R. Frowler and Ernest W. Smith, Nov., 762

- radiotracer studies on bone, cementum, dentin and enamel of Rhesus monkeys (ab), Reider D. Sognnaes et al., Dec., 965

TEICHERT, G.: Contribution to the analysis of knee-joint

- roentgenograms (ab), Nov., 818

TELANGIECTASIS

- hereditary hemorrhagic telangiectasis; report of pulmonary arteriovenous fistulae in mother and son: medical (hormonal) and surgical therapy of this disease (ab), Edward C. Heyde, Sept., 466

- pulmonary arteriovenous fistula and telangiectasia (ab), Eugene Weiss and Benjamin M. Gasul, Sept., 465

- pulmonary arteriovenous telangiectasia (ab), Fred N. Mitchell, Nov., 802

TELEPAQUE. See Gallbladder, roentgenography**TELEVISION**

- practical image amplifier technics: fluoroscopy, cinefluorography, spot film radiography and use with closed circuit television, Herbert M. Stauffer, Morton J. Oppenheimer, George H. Stewart III, and Archie W. Blackstone, Nov., 784

TEMESVARI, A. See KISFALUDY, P.**TEMPERATURE.****See also Cold**

- study of effect of high temperature by hot baths, short waves and ultrasonics on cancer tissue and biological principles of combined x-ray-ultrasonics therapy of superficial tumors (ab), Karlheinz Woeber, Sept., 488

- TERATOMA.** See Tumors, teratoma
- TERIDAX.** See Gallbladder
- TERNER, I. S.** See EISENBERG, I. J.
- TER-POGOSSIAN, MICHEL, and SHERMAN, ALFRED I.:** Radioactive gold for the intracavitary treatment of carcinoma of the cervix, Nov., 779
- See **SEAMAN, WILLIAM B.**
- TESCHENDORF, WERNER:** Visualization of the biliary tract by means of Biligrafin, especially after cholecystectomy (ab), Aug., 305
- See **GAEBEL, E.**
- TESTES**
- tumors**
- (ab), Samuel L. Raines and Thomas G. Hurdle, Dec., 961
- adrenal response to irradiation on patients with testicular tumors (ab), Ward O. Soanes and Claude C. Dodson, Aug., 315
- analysis of 80 cases (ab), Gilbert J. Thomas and Arthur J. Bischoff, July, 148
- radiotherapy in malignant disease of testicle and penis (ab), Robert Cox, Oct., 645
- teratoma: 100 consecutive cases (ab), Jack W. Schwartz and Nicholas Mallis, July, 147
- testicular cancer: management of metastases, with report of a new chemotherapeutic agent (Nitrofurazone), Orliss Wildermuth, Oct., 599
- TETRALOGY OF FALLOT.** See Heart, abnormalities
- TEXTILE INDUSTRY.** See Pneumoconiosis
- THEODOS, PETER A.** See **BOUCOT, KATHARINE R.**
- THEVENET, A.** See **BALMES, A.**
- THIEMANN'S DISEASE.** See Fingers and Toes
- THOMAS, CHARLES L., KROHMER, JACK S., and STORAASLI, JOHN P.:** Geiger counter probe for diagnosis and localization of posterior intraocular tumors (ab), July, 154
- THOMAS, GILBERT J., and BISCHOFF, ARTHUR J.:** Tumors of the testis: analysis of 80 cases (ab), July, 148
- THOMAS, SYDNEY F.** See **KRISS, JOSEPH P.**
- THOMMEN, B.:** Some radiological aspects of the resected stomach (ab), Sept., 469
- THOMPSON, E. C.** See **BRACE, K. C.**
- THOMSEN, GREGERS.** See **GUDEBJERG, CARL E.**
- THORACIC DUCT**
- some serious complications of tuberculous lymph nodes: fatal hemoptysis, false aneurysm, occluded cisterna chyli and obstructive jaundice: review, with report of 5 cases (ab), Godfrey L. Gale, Sept., 463
- THORAEUS, R.** See **BENNER, S.**
- THORAX**
- See also Heart; Lungs; Mediastinum; etc.
- energy distribution in thorax during multiple field and rotational therapy (ab), Joseph R. Nahon and John B. Hawkes, Sept., 483
- meningoceles of intrathoracic development (ab), Ch. Gernez-Rieux and G. Lepaul, July, 127
- thoracic outlet syndrome: case associated with short "first" rib, aneurysm of the subclavian artery and occlusion of brachial artery (ab), J. R. E. Fraser and A. J. Barnett, Sept., 476
- thoracic volume and obesity (ab), R. Pohl and O. Scharff, Dec., 950
- roentgenography.** See also Tuberculosis, Pulmonary, mass roentgenologic surveys
- diagnosis of hiatus hernia on plain roentgenograms of thorax and abdomen (ab), Francis J. O'Connor and Max Ritvo, Nov., 814
- experience with large routine chest film in rural hospital (ab), J. W. Boyd, Aug., 293
- program for roentgen examination of hospital admissions (ab), Caroline W. Rowe, Aug., 293
- value of routine chest x-ray film in detecting diaphragmatic hernia: 53 cases (ab), Abel Froman, Aug., 306
- tumors**
- radiotherapeutic test: an unreliable diagnostic procedure in intrathoracic mass lesions, Eugene R. Kutz, Sept., 378
- THORAZINE.** See Chlorpromazine Hydrochloride
- THORIUM**
- See also Thorotrast
- K V: a large 4 x gamma ray detector (ab), M. A. Van Dilla et al., July, 154
- THOROTRAST (Thorium Dioxide)**
- effect of repeated injections of Thorotrast on antibody production (ab), Lena A. Lewis, Oct., 652
- late clinical changes following internal deposition of radioactive materials (ab), William B. Looney, Dec., 967
- THREEFOOT, S. A., BURCH, G. E., and RAY, C. T.:** Biologic decay rates and excretion of radiocesium, ^{137}Cs , with evaluation as a tracer of potassium in dogs (ab), Dec., 967
- See **RAY, C. T.**
- THROMBOPHLEBITIS**
- unusual case of thrombophlebitis and a new type of venogram (ab), M. F. A. Woodruff, Sept., 467
- THROMBOSIS**
- differential diagnosis of hiatus hernia: recurrent thromboses as symptom of hiatus hernia (ab), T. Wegmann, Sept., 472
- collateral circulation of external carotid artery and internal carotid artery through ophthalmic artery in cases of internal carotid artery thrombosis: 5 cases, Paul M. Lin and Michael Scott, Nov., 755
- THYMOA.** See Thymus
- THYMUS**
- studies on thymus (ab), A. Torsoli et al., Dec., 950
- thymoma: diagnosis and treatment (ab), William Weingarten and Glenn Gordon, Dec., 950
- THYROID**
- accumulation and destructive action of astatine²¹¹ (EKA-iodine) in thyroid gland of rats and monkeys (ab), Joseph G. Hamilton et al., Aug., 320
- effects of thyroid function on insulin-¹³¹I degradation (ab), Neil J. Elgee and Robert H. Williams, Nov., 829
- estimation of thyroid volume: an anatomic study of correlation between frontal silhouette and volume of gland (ab), Erkki Himanka and Lars-Gunnar Larsson, Dec., 962
- histologic effects of various types of ionizing radiation on normal and hyperplastic human thyroid glands (ab), Stuart Lindsay et al., Aug., 320
- iodinated compounds in serum, disappearance of radioactive iodine from thyroid, and clinical response in patients treated with radioactive iodine (ab), Richard S. Benna and Brown M. Dobyns, Nov., 827
- mechanism of induction and characteristics of pituitary tumors induced by thyroidectomy (ab), Jacob Furth et al., Nov., 828
- radioactive iodine therapy in euthyroid cardiac patient with previous mitral commissurotomy (ab), Frederick W. Pobirs and Henry L. Jaffe, Dec., 962
- studies with radioiodine. IV. Collimating cones for crystal counters, Earl R. Miller and Norman E. Scofield, July, 96
- studies with radioiodine. V. Validity of histologic determination of ¹³¹I radiation changes in thyroid gland, Earl R. Miller, Stuart Lindsay, and Morris E. Dailey, Sept., 384
- treatment of incapacitated euthyroid cardiac patients with radioactive iodine: summary of results in 1,070 patients with angina pectoris or congestive failure (ab), Herman L. Blumgart et al., Nov., 827
- aberrant**
- radioiodine tests in case of struma ovarii (ab), John F. Foulkes and Russell Fraser, Aug., 317
- cancer**
- quantitative measurements of radioiodine retention in carcinoma (ab), E. Eric Pochin et al., Sept., 485
- radiotherapy: Mackenzie Davidson Memorial Lecture (ab), B. W. Windeyer, Aug., 314
- function tests**
- continuous registration of thyroid uptake after intravenous injection of radioactive iodine: a rapid test of iodine concentrating function of thyroid (ab), Lars-Gunnar Larsson and Lars Jonsson, Nov., 827
- diagnostic use of ¹³¹I (ab), E. M. Hanbury, Jr., et al., Oct., 647
- distribution of radioiodine observed in thyroid disease by means of Geiger counters—its determination and significance (ab), J. P. Nicholson et al., Sept., 486
- evaluation of methods of measuring the accumulation of ¹³¹I by thyroid gland, John P. Storaasli, William J. MacIntyre, Hymer L. Friedell, and Keith E. Weigle, Jr., Oct., 489
- in vitro studies of intact thyroid gland (ab), A. L. Botkin et al., Aug., 317
- influence of various factors on uptake of iodine (ab), D. Ward Slingerland, Nov., 828
- metabolism of iodine in 2 goitrous cretins compared with that in 2 patients receiving methimazole (ab), John B. Stanbury et al., Nov., 828
- method for increasing the accuracy of radioiodine uptake as test for thyroid function by use of desiccated thyroid (ab), Monte A. Greer and G. Edward Smith, Sept., 485
- radioactive iodide uptake of normal newborn infants (ab), L. Van Middlesworth, Aug., 316
- simplified sensitive test for thyroid function, using protein-bound ¹³¹I (ab), L. Van Middlesworth et al., July, 151
- studies on thyroidal uptake of astatine in rat (ab), C. J. Shellabarger and John T. Godwin, Aug., 320
- uptake of radioactive iodine in thyroid of patients with impaired liver function (ab), Richard Mueller et al., Sept., 485
- hyperthyroidism**
- clinical use of plasma butanol extractable (thyroxin) ¹³¹I in diagnosis of hyperthyroidism and myxedema (ab), Alvin L. Schultz et al., July, 151
- comparative value of basal metabolic rate, chemical protein-bound iodine, and radioactive iodine excretion or uptake in diagnosis of borderline hyperthyroidism when used individually or in combination (ab), Leslie Zieve et al., Dec., 962
- radiation cancer of pharynx (following radiotherapy for thyrotoxicosis) (ab), Ronald W. Raven and V. B. Levison, Aug., 320
- renal function and ¹³¹I clearance in hyperthyroidism and myxedema (ab), Charles J. Hlad, Jr., and Neal S. Bricker, Oct., 647
- simultaneous measurement of iodide concentrating and protein-binding capacities of normal and hyperfunctioning human thyroid gland (ab), Sidney H. Ingbar, Dec., 962
- therapeutic studies: use of radioactive iodine (ab), Herman Stone et al., July, 150
- hypothyroidism**
- hypothyroidism and thyroid hyperplasia in patients treated with cobalt (ab), Joseph P. Kriss et al., Nov., 829
- metabolism of iodine in 2 goitrous cretins compared with that in 2 patients receiving methimazole (ab), John B. Stanbury et al., Nov., 828
- therapy**
- method for increasing accuracy of radioiodine uptake as test for thyroid function by use of desiccated thyroid (ab), Monte A. Greer and G. Edward Smith, Sept., 485

THYROTOXICOSIS. See Thyroid, hyperthyroidism**THYROXIN**

—clinical use of plasma butanol-extractable (thyroxin) ¹³¹I in diagnosis of hyperthyroidism and myxedema (ab), Alvin L. Schulte et al., July, 151

TIDRICK, ROBERT T. See GIUS, JOHN A.

TILL, J. E. See JOHNS, H. E.

TILLET, JOHN V. See SUTTON, DAVID

TIN

—benign tin oxide pneumoconiosis (ab), George E. Spencer and William C. Wycoff, Aug., 293

TIRONA, JOSÉ P.: The roentgenological and pathological aspects of tuberculosis of the skull (ab), Sept., 461

TOCHILIN, E.: A photographic method for measuring the distribution of dosage from radium needles and plaques (ab), Dec., 961

TODD, WILLIAM A., Jr. See DOWNS, CHARLES R.

TOMOGRAPHY. See Body Section Roentgenography

TONSILS

—treatment of malignant tumors of tonsillar region and soft palate (ab), P. Kisfaludy et al., Nov., 826

TORSOLI, A., SARTESCHI, G., MELE, M., and SBRANA, E.: Studies on the thymus (ab), Dec., 950

TORULOSIS

—cryptococcosis with involvement of lungs and spine; case (ab), David Eisen et al., Nov., 802

TOTTEN, H. P.: Peripheral arteriosclerosis. Clinical and arteriographic evaluation with reference to conservative surgical treatment (ab), Aug., 299

TOVELL, H. M. M. See GUSBERG, S. B.

—See CORSCADEN, JAMES A.

TOXOPLASMOSIS

—roentgen findings and intracerebral calcifications in congenital toxoplasmosis (ab), J. François and Fr. De Witte, Nov., 796

TRABUCCO, ARMANDO, and MÁRQUEZ, FERNANDO: The venous junction of the glomerular artery (ab), Oct., 631

TRACHEA

—clinical survey of adenomas of trachea and bronchus in general hospital (ab), Lamar Soutter et al., Aug., 292

—tracheographic and bronchographic studies as aids in diagnosis of congenital malformations of tracheobronchial tree and aortic arch in infants and children (ab), Charles F. Ferguson and Carlyle G. Flake, Oct., 628

TRACHTMAN, BENJAMIN. See KATZEN, PERRY

TRAUMA. See Aneurysm, aortic; Brain; Elbow; Fingers and Toes; Gallbladder

TREDER, FREDERICK H. See BATT, HAROLD D.

TRESIDDER, G. C.: Ureterograms (ab), July, 144

TRICHINELLA

—studies on nature of immunity to *Trichinella spiralis* in parathion rats. VII. Immune response of "uninfected" twin one month after its mate received an immunizing dose of irradiated (x-ray) larvae (ab), Herman Zaiman et al., Nov., 833

TRICOMI, GAETANO. See PIGORINI, LUIGI

TRICUSPID VALVE

—Ebstein's anomaly; case diagnosed during life (ab), A. J. Kerwin, Nov., 805

TRIURUL. See Brain, blood supply

TROUT, E. DALE, KELLEY, JOHN P., LUCAS, ARTHUR C., and FURNO, EDWARD J.: Isodose curves for superficial therapy, Nov., 703

TRUM, BERNARD F. See HALEY, THOMAS J.

TRUMP, JOHN G. See BOYD, DAVID P.

TRUNCUS BRACHIOCEPHALICUS. See Arteries, innominate

TUBERCULOMA. See Lungs, tumors

TUBERCULOSIS. See Bones; Fallopian Tubes; Intestines; Lymph Nodes; Tuberculosis, Pulmonary; etc.

TUBERCULOSIS, PULMONARY

—indications for x-ray examination of intestinal tract in patients with pulmonary tuberculosis (ab), H. Erdmann, Aug., 303

—regressive giant bullous emphysema in tuberculosis of adults (ab), Donato G. Alarcon, Nov., 801

—tuberculo-silicosis (ab), F. S. du Toit, Sept., 463

—coexistent tuberculosis and carcinoma of lung, Harry Hauser and Norman M. Glazer, Nov., 680

mass roentgenologic surveys

—case findings from routine chest roentgenograms. Mass surveys of communities versus general hospital admissions (ab), William Siegal et al., Nov., 799

—chest surveys: a symposium, L. H. Garland, Moderator, July, 19-30

—hospital administrator looks at chest surveys, Ray R. Brown, July, 22

—Los Angeles x-ray survey film and record library, its past development, present activities and future possibilities (ab), Blanche Perkins and Emil Bogen, Dec., 948

—mass x-ray survey: city of Sydney (ab), Charles Rubinstein, Nov., 799

—radiologist and chest surveys, T. J. Wachowski, July, 19

—routine chest films of hospital admissions from standpoint of specialist in diseases of chest, Edwin R. Levine, July, 24

—undetected tuberculosis in various economic groups (ab), Robert J. Anderson et al., Sept., 462

—what the public thinks of chest surveys, Robin Buerki, July, 26

roentgenography. See also Tuberculosis, Pulmonary, mass roentgenologic surveys

—bronchography with Dinosaal (ab), Conway Don, Nov., 800

surgical therapy

—mediastinal emphysema as a complication of therapeutic pneumoperitoneum (ab), B. Mukherjee and K. R. Adhikary, Oct., 628

therapy

—Milkman's pseudofractures of ribs following extraperiosteal Ivalon pack, Samuel L. Cohen, Oct., 587

—roentgenologic changes of lung associated with Isoniazid therapy (ab), David Salkin and J. A. Schwartz, July, 126

TUBES. See Roentgen Rays, apparatus

TUCKER, W. D. See HANBURY, E. M., Jr.

TULLIS, JOHN L., LAMSON, BALDWIN G., and MADDEN, SIDNEY C.: Pathology of swine exposed to total body gamma radiation from an atomic bomb source (ab), Nov., 833

TULSKY, ALEX. See KUNSTADTER, RALPH H.

TUMOR

See also Cancer; Sarcoma; and under names of organs and regions

adamantinoma

—roentgen appearance of adamantinoma of mandible, Robert S. Sherman and Hugh Caumartin, Sept., 361

adenoma. See also Bronchi, tumors; Lungs, cancer; Parathyroid

—bilateral polyadenomatous kidneys: adenomatosis of kidneys simulating polycystic disease (ab), Herman J. Meisel, Oct., 640

—diagnosis of renal adenoma (ab), Jan Kučera and Čestmír Dvořáček, Nov., 822

adenomyoma

—gastric adenomyosis vs. aberrant pancreas, Christian V. Cimmino, July, 73

angioma. See also Telangiectasis

—pneumographic aspect of the angioreticuloma (hemangioblastoma) of cerebellum (ab), Giovanni Ruggiero and Francesco Castellano, Oct., 625

—retroperitoneal cavernous hemangioma associated with hemangiomas of skin in a newborn; case report and brief review of literature (ab), J. Richards Aurelius et al., Nov., 812

—treatment of hemangioma of skin in infancy and childhood by roentgen irradiation and radium; 323 cases (ab), Anis Abdulkerim et al., Sept., 482

animal. See Tumors, experimental

experimental

—effects of antitumor drugs upon P³² incorporation into nucleic acids of mouse tumors (ab), Jack D. Davidson and Betty B. Freeman, Nov., 830

—lack of effect of adrenalectomy on tumor regression following x-irradiation (ab), Joanne W. Hollcroft and Marion Matthews, Aug., 322

—study of effect of high temperature by hot baths, short waves and ultrasonics on cancer tissue and biological principles of combined x-ray-ultrasonics therapy of superficial tumors (ab), Karlheinz Woebber, Sept., 488

fibroma

—ossifying fibromas (fibrous dysplasia) of facial bones in children and adolescents (ab), Nicholas Georgiade et al., Nov., 796

hemangioma. See Tumors, angioma

lymphoma. See also Hodgkin's Disease

—gastric lymphoma, Gordon J. Culver, Berten C. Bean and David L. Berens, Oct., 518

—malignant lymphoma: radiological aspects (ab), K. M. Rai, Dec., 959

—radiation therapy in management (ab), Simeon T. Cantril, Sept., 484

melanoma

—malignant melanoma of small intestine, Michael F. Beirne, Nov., 749

—treatment of malignant melanomas (ab), Heribert Müller-Miny, Dec., 959

mesothelioma

—peritoneal mesothelioma; case (ab), E. P. Pendergrass and Jack Ediken, July, 148

—pleural mesothelioma; 4 cases (ab), George M. Bogardus et al., Dec., 949

—roentgen aspects of pleural mesothelioma, Nathaniel Finby and Israel Steinberg, Aug., 169

myeloma. See Bones, marrow

myoma

—leiomyoma of stomach (ab), Herbert L. Abrams, Oct., 634

—opacification of a calcified leiomyoma during hysterolap-pingography (ab), Meyer Alpert and B. Douglas Lecher, July, 142

osteochondroma

—of lumbar spine; case (ab), Husameddin Gokay and Paul C. Bucy, Nov., 816

osteoma

—anatomic-radiographic picture of giant osteomas in paranasal sinuses (ab), Giuseppe Muscettola, Sept., 461

papilloma

—treatment of papilloma of bladder with radioactive colloidal gold, Au¹⁹⁸ (ab), Frank Ellis and R. Oliver, Nov., 830

pheochromocytoma

—case (ab), S. J. Forrest and L. Goldberg, July, 143

polyp

—benign gastric polyps (ab), David Niemets and George K. Wharton, Dec., 952

teratoma

—teratoma testis; 100 consecutive cases (ab), Jack W. Schwartz and Nicholas Mallis, July, 147

tuberculoma. See Lungs, tumors.

- TURNBULL, A. C.:** Radium menopause or hysterectomy. Part I. The effects of the radiation menopause, a controlled study (ab), Dec., 900
- TURNER, OTIS D.** See **ANDERSON, ROBERT J.**
- TWISS, J. RUSSELL, GILLETTE, LEE, BERANBAUM, SAMUEL I., POPPEL, MAXWELL H., and HANSEN, ELLIF C.:** Postcholecystectomy oral cholangiography (ab), Nov., 812
- TYOR, MALCOLM P.** See **ROOT, SAMUEL W.**
- U**
- ULCERS.** See Peptic Ulcer
- ULTRASONICS THERAPY.** See Tumors, experimental
- UNIVERSITIES**
—protection measures in a university, Titus C. Evans, Dec., 875
- UPHAM, HARVEY C.** See **DETRICK, LAWRENCE E.**
- UPTON, A. C., FURTH J., and CHRISTENBERRY, K. W.:** Late effects of thermal neutron irradiation in mice (ab), Aug., 323
- and **GUDE, W. D.:** Physiologic and histochemical changes in connective tissue of rat induced by total body irradiation (ab), July, 155
- URETERS**
—foreign body in left kidney and ureter (ab), Bela Gondos, Nov., 821
- abnormalities**
—diagnosis of vaginal ectopic ureter by vaginogram (ab), Perry Katzen and Benjamin Trachtman, Sept., 481
- ectopic ureter; diagnostic problems (ab), D. Innes Williams, July, 143
- triplicate ureter (ab), Herbert D. Axilrod, Sept., 481
- dilatation**
—neuromuscular disorders of the urinary tract in children (megalo-ureter), R. Parker Allen, Sept., 325
- roentgenography**
—ureteral jet phenomenon: stream of opaque medium simulating an anomalous configuration of the ureter, Edmond H. Kalmou, Donald D. Alpers, and J. Hartwell Dunn, Dec., 933
- ureterograms (ab), G. C. Tresidder, July, 144
- URETHRA**
—complications of "osteitis pubis," including report of case of sequestrum formation giving rise to persistent purulent urethritis (ab), B. D. Stutter, July, 138
- urethrography in male: the boundaries of different urethral parts and detail studies of urethral mucous membrane and its motility (ab), Olallo Morales and Ragnar Romanus, Nov., 822
- URINARY TRACT**
See also Bladder; Kidneys; Pyelography; Ureters; Urethra
—arthritis of hip following urinary tract operation, Edwin L. Lame, Aug., 194
- spinal osteomyelitis associated with urinary tract infections, Ted F. Leigh, Robert P. Kelly, and H. Stephen Weems, Sept., 334
- calculi.** See Kidneys, calculi
- tumors**
—ill-effects of radiotherapy (ab), D. M. Wallace, Oct., 645
- irradiation therapy in urology (ab), George W. Blomfield, Oct., 644
- URINE AND URINATION**
—hypercalciuria and metabolic bone disease (ab), Milton L. Rosenberg, Oct., 641
- normal micturition: certain details as shown by serial cystograms (ab), Frank Hinman, Jr., et al, Nov., 821
- UROGRAPHY.** See Pyelography
- USHER, FRANCIS C.** See **OVERTON, ROBERT C.**
- UTERUS**
—radium menopause or hysterectomy. Part I. The effects of the radiation menopause. A controlled study (ab), A. C. Turnbull, Dec., 900
- abnormalities**
—uterus duplex unicollis (ab), Benedict B. Benigno, July, 142
- cancer**
—carcinoma of cervical stump (ab), J. R. Dodds and J. P. A. Latour, Dec., 960
- cervical cancer (ab), A. N. Arneson, July, 146
- cervical cancer: curability of regional lymph node metastases (ab), John B. Graham and Ruth M. Graham, Dec., 959
- cervical cancer: further observations on tissue dosage (ab), Manuel Garcia, Nov., 824
- cervical cancer: radiosensitivity testing; preliminary report (ab), S. B. Gusberg et al, Oct., 643
- cervical cancer: study of radiation dosimetry in treatment (ab), George C. Lewis, Jr., et al, Oct., 643
- cervical cancer: transvaginal roentgen therapy in cancer of stump (ab), Ralph M. Caulk, July, 147
- cervical carcinoma: dosage distribution in pelvis in radium treatment (ab), Rune Walstam, July, 146
- cervical carcinoma: effect of Cortate and of Dramamine on selected group of patients undergoing deep roentgen therapy (ab), E. C. Lasser and K. W. Stenstrom, Sept., 487
- cervical carcinoma: radioactive gold for intracavitary treatment, Michel Ter-Pogossian and Alfred I. Sherman, Nov., 779
- cervical carcinoma: results obtained from irradiation of parametrium with radioactive colloidal gold (ab), William M. Allen et al, Oct., 647
- cervical carcinoma: results of radiation therapy at First Gynecological Clinic of the University of Munich in the years 1947 and 1948 (ab), Heinrich Eymer and Julius Ries, Sept., 483
- cervical carcinoma treated at American Oncologic Hospital, 1929-1949 (ab), George A. Hahn, Nov., 824
- development of endometrial carcinoma subsequent to irradiation for carcinoma of cervix (ab), Frederick P. Zuspan, Nov., 832
- effects of irradiation of pelvis in patients with carcinoma of cervix uteri on iliac and sternal marrow and on peripheral blood (ab), Lucile W. Hutaff and Helen W. Belding, Dec., 967
- management of carcinoma of corpus (ab), James A. Corca-den and Harold M. M. Tovell, July, 147
- cervix.** See Uterus, cancer
- diseases**
—deep x-ray therapy in gynecology (ab), E. J. B. Hardcastle, Nov., 823
- roentgenography.** See Fallopian Tubes; Uterus, tumors
- tuberculosis.** See Fallopian Tubes, tuberculosis
- tumors**
—opacification of calcified leiomyoma during hysterosalpingography (ab), Meyer Alpert and B. Douglas Lecher, July, 142
- V**
- VACUUM PHENOMENON.** See Spine, intervertebral disks
- VAGINA**
—diagnosis of vaginal ectopic ureter by vaginogram (ab), Perry Katzen and Benjamin Trachtman, Sept., 481
- opaque vaginal suppository mistaken for bladder calculus (letter to editor), George E. Irwin, Jr., Nov., 788
- VALVERDE, MARIANO.** See **AJAMIL, LUIS F.**
- VAN DILLA, M. A., SCHUCH, R. L., and ANDERSON, E. C.:** K-9: a large γ gamma-ray detector (ab), July, 154
- VÁNDOR, F.** See **KISFALUDY, P.**
- VAN MIDDLESWORTH, L.:** Radioactive iodide uptake of normal newborn infants (ab), Aug., 316
- NURNBERGER, C. E., and LIPSCOMB, ALYS:** Simplified sensitive test for thyroid function, using protein-bound I^{131} (ab), July, 151
- VARICOSE VEINS**
—venography and the approach to varicose veins (ab), Ian F. K. Muir et al, Sept., 467
- VAS DEFERENS**
—vaso-epididymography and vaso-epididymography (ab), Benjamin S. Abeshouse et al, Sept., 481
- VATER'S AMPULLA**
—primary malignancies of papilla of Vater; case report and review (ab), Austin P. Boleman, Jr., and Leonard Breslaw, Oct., 636
- VATER'S PAPILLA.** See **VATER'S AMPULLA**
- VAZQUEZ, JACINTO J.** See **SCHLUMBERGER, HANS G.**
- VEALL, N.** See **MOLLISON, P. L.**
- VEINS**
See also Portal Vein; Venae Cavae
- cerebral**
—vascular malformations in region of great vein of Galen (ab), Lyle A. French and William T. Peyton, July, 126
- esophageal**
—visualization of gastric and lower esophageal veins by splenoportography in case of carcinoma of lesser curvature (ab), D. Catalano and S. Riccio, July, 130
- Galen's.** See Veins, cerebral
- gastric**
—visualization of gastric and lower esophageal veins by splenoportography in case of carcinoma of lesser curvature (ab), D. Catalano and S. Riccio, July, 130
- obstruction.** See Extremities, blood supply
- pulmonary.** See also Fistula, arteriovenous; Lungs, blood supply
—anomalous pulmonary vein drainage into coronary sinus (ab), M. W. Arthurton et al, Aug., 298
- drainage of right pulmonary vein into inferior vena cava; report of case, with radiologic analysis of principal types of anomalous venous return from lung (ab), Victor A. McKusick and Robert N. Cooley, Dec., 951
- roentgen appearance in heart disease, Howard L. Steinbach, Theodore E. Keats, and Glenn E. Shelton, Aug., 137
- roentgenography.** See Brain, tumors; Extremities, blood supply; Portal Vein; other subheads under Veins
- splenic**
—visualization of gastric and lower esophageal veins by splenoportography in case of carcinoma of lesser curvature (ab), D. Catalano and S. Riccio, July, 130
- subclavian.** See Fistula, arteriovenous
- umbilical**
—venography in diagnosis of Cruveilhier-Baumgarten syndrome (ab), Charles M. Caravati and James M. MacMillan, Sept., 467
- varicose.** See Varicose Veins
- vertical**
—left-sided superior vena cava (ab), Maurice Campbell and D. C. Deuchar, Aug., 297
- VENAE CAVAE**
—cavography and mediastinal pathology (ab), Jarro Rosati, Nov., 807
- drainage of right pulmonary vein into inferior vena cava; report of case, with radiologic analysis of principal types of anomalous venous return from lung (ab), Victor A. McKusick and Robert N. Cooley, Dec., 951

VENAE CAVAE—cont.

—visualization of inferior vena cava as adjunct to diagnosis of retroperitoneal tumors; case (ab), John M. Keshishian and William A. Spencer, Oct., 630

—persistent left vena cava. See Veins, vertical

VENOGRAPHY. See Cruveilhier-Baumgarten Syndrome; Thrombophlebitis; Varicose Veins

VEREL, D.: Treatment of polycythemia rubra vera with radioactive phosphorus (ab), Aug., 317

VERMOOTEN, VINCENT: Use of radioactive cobalt (Coss) in nylon sutures in treatment of carcinoma of bladder: Preliminary report (ab), Dec., 963

VERSEN, E. See HAUBRICH, R.

VERTEBRA PLANA. See Spine

VERTEBRAE. See Spine

VIKTERLOF, K. J. See BENNER, S.

VITAMINS

—clinical picture of vitamin-D-resistant rickets ("phosphate diabetes") (ab), W. Swoboda and W. Rupp, Sept., 474

—surface scintillation measurements in humans of uptake of parentally administered radioactive vitamin B₁₂ (ab), George B. Jerzy Glass et al. Dec., 966

VOGL, ALFRED, BLUMENFELD, SERGE, and GUTNER, LEONARD B.: Diagnostic significance of pulmonary hypertrophic osteoarthropathy (ab), Nov., 814

VOGLER, E.: Angiographic observations on the development of vascular disease and circulatory disturbances, with special attention to the terminal vessels (ab), Aug., 300

VOJTEK, C.: The neural conception of the treatment of purulent skin disease by roentgen irradiation (ab), Nov., 825

VOLVULUS. See Intestines; Stomach

W

WACHOWSKI, T. J.: Chest surveys. The radiologist and chest surveys, July, 19

WALKER, A. EARL. See KAPLAN, ALBERTO D.

WALKER, C. S.: Calcification of intervertebral discs in children (ab), Sept., 477

WALKER, RHEY. See MILLER, FRANK L.

WALL, A. E.: A note on the diagnosis of meningiomas within the lateral ventricles of the brain (ab), Aug., 291

WALLACE, D. M.: The ill-effects of radiotherapy (ab), Oct., 645

WALSTAM, RUNE: Dosage distribution in the pelvis in radium treatment of carcinoma of the cervix (ab), July, 146

WALTER, J. B. See HOUGHTON, L. E.

WANKE, R.: Problems in the therapy of breast cancer (ab), Dec., 959

WARD-McQUAID, J. N. See DANIEL, P. M.

WARNER, A. L., PALLADINO, N. M., SCHWARTZ, W., and SCHUSTER, A.: The relationship of agenesis of the lung to emphysema and cor pulmonale (ab), Nov., 946

WATSON, DERRELL D. See ADLER, DENIS C.

WEBSTER, J. E. See LOFSTROM, J. E.

—See MARTIN, F. A.

WEENS, H. STEPHEN, and FLORENCE, THOMAS J.: Diagnosis of hydronephrosis by percutaneous renal puncture (ab), Aug., 311

—See LEIGH, TED F.

WEGELIUS, CARL. See LIND, JOHN

WEGMANN, T.: Differential diagnosis of hiatus hernia: recurrent thromboses as symptom of hiatus hernia (ab), Sept., 472

WEIGLE, KEITH E., Jr. See STORAASLI, JOHN P.

WEINGARTEN, WILLIAM, and GORDON, GLENN: Thyromyoma: diagnosis and treatment (ab), Dec., 950

WEINGRABER, H.: A new observation in a case of hyperostotic osteopathy of Engelmann-Camurati (ab), Oct., 639

WEISBERGER, AUSTIN S., and LEVINE, BENNETT: Incorporation of radioactive L-cystine by normal and leukemic leukocytes in vivo (ab), Oct., 649

—SUHLAND, LEIF G., and GRIGGS, ROBERT C.: Incorporation of radioactive L-cystine and L-methionine by leukemic leukocytes in vitro (ab), Oct., 649

WEISS, EUGENE, and GASUL, BENJAMIN M.: Pulmonary arteriovenous fistula and telangiectasia (ab), Sept., 465

WEISSMAN, S. L.: Congenital dysplasia of the hip. Observations of the "normal" joint in cases of unilateral disease (ab), Aug., 307

WELLS, C. R. E. See GLOVER, ROBERT P.

WEYDE, ROLF: Abdominal aortography, with special reference to kidney diseases (ab), Sept., 480

WHARTON, GEORGE K. See NIEMETZ, DAVID

WHEELER, H. BROWNELL, JAMES, WILLIAM E., and BOTSFORD, THOMAS W.: Experiences with the use of radioactive colloidal gold in the treatment of cancer (ab), Dec., 964

WHIPLASH INJURY. See Spine

WHITE, T. G. E. See PIMBLETT, G. W.

WHITEHOUSE, WALTER M.: A comparative clinical study of Teridax (3 gm.) and Telepaque (2 gm.) in routine cholecystography, Sept., 425

—Correlation of surgical pathology with Telepaque cholecystography in doses of two grams (ab), Dec., 953

—See HAAS, R. L.

—and MARTIN, O.: Clinical and roentgenologic evaluation of routine 2-gram Telepaque dosage in cholecystography, Sept., 422

WHITELEATHER, JOHN E.: Roentgen demonstration of cervical nerve root avulsion (ab), Oct., 638

WHITELEY, M. M. See CAVE, A. J. E.

WHITROCK, ROBERT M. See KEATS, THEODORE E.

WIDERÖE, R. See SCHINZ, H. R.

WIGBY, PALMER E. See LEMAK, LESLIE L.

WIGH, RUSSELL. See SHIPP, JOSEPH C.

WILDERMUTH, ORLISS: Testicular cancer: management of metastases, with report of a new chemotherapeutic agent, Oct., 599

WILENSKY, NATHAN D. See LANGSAM, MARTIN

WILHELM, SEYMOUR F.: Gas insufflation through the lumbar and presacral routes (ab), July, 146

WILLIAMS, D. INNES: The ectopic ureter; diagnostic problems (ab), July, 143

WILLIAMS, FRANCIS B. (obit), Aug., 284

WILLIAMS, GEORGE Z. See NELSON, CHARLES M.

WILLIAMS, IFOR: Calcification in lolas (ab), Aug., 312

WILLIAMS, ROBERT H. See ELGEE, NEIL J.

WILLIAMS, ROHAN: Complete protrusion of a calcified nucleus pulposus in the thoracic spine. Report of a case (ab), Sept., 478

WILLIAMS, S. F. See FLYNN, J. E.

WILLIS, G. C., LIGHT, A. W., and GOW, W. S.: Serial arteriography in atherosclerosis (ab), Oct., 632

WILLMANN, K. H. See LANGER, E.

WILLSON, JAMES K. V. See GOULD, DAVID M.

WILSON, CHARLES W. See SMITH, PHILIP W.

—See CREGG, H. A.

WILSON, C. W. See NICHOLSON, J. P.

WILSON, P. A. O. See WOOD, PAUL

WILSON, THEODORE, W., and PUGH, DAVID G.: Primary recticulum-cell sarcoma of bone, with emphasis on roentgen aspects, Sept., 343

WINDEYER, B. W.: Cancer of the thyroid and radiotherapy. Mackenzie Davidson Memorial Lecture (ab), Aug., 314

WINTER, MELVIN. See MESCHAN, ISADORE

WINTROBE, M. M., CARTWRIGHT, G. E., FESSAS, PHAEDON, HAUT, ARTHUR, and ALTMAN, S. J.: Chemotherapy of leukemia, Hodgkin's disease and related disorders (ab), July, 148

WIRSUNG'S DUCT. See Pancreatic Ducts

WISDOM, W. R. See COSTLOW, W. E.

WOEBER, KARLHEINZ: Study of the effect of high temperature by hot baths, short waves and ultrasonics on cancer tissue and biological principles of combined x-ray-ultrasonics therapy of superficial tumors (ab), Sept., 488

WOLF, BERNARD S. See MARSHAK, RICHARD H.

WOO, ZUNG-PAH. See ST. JOHN, ELMER G.

WOOD, PAUL, MAGIDSON, O., and WILSON, P. A. O.: Ventricular septal defect, with a note on acyanotic Fallot's tetralogy (ab), Aug., 294

WOODARD, HELEN Q. See FRANCIS, KENNETH C.

WOODRUFF, M. F. A.: An unusual case of thrombophlebitis and a new type of venogram (ab), Sept., 467

WOODWARD, G. M. See ARTHURTON, M. W.

WORD, ELIZABETH L. See CHANUTIN, ALFRED

WRIGHT, A. W. See GORHAM, L. W.

WYCOFF, WILLIAM C. See SPENCER, GEORGE E.

WYMAN, STANLEY M.: Angiocardiology: a guide to medical exploration (ab), Aug., 295

—See CHAPMAN, WILLIAM P.

X-Y-Z

XERORADIOGRAPHY

—(ab), John F. Roach and Herman E. Hilleboe, Aug., 312

YANG, SZE-PIAO, CHENG, C. S., and GHEN, K. M.: Chest x-ray findings and some clinical aspects in pulmonary paragonimiasis (ab), Nov., 803

YDEN, S. See MÄRTENSSON, G.

YLINEN, OLLI, and JOHANSON, C.-E.: Role of hysterosalpingography in the diagnosis of genital tuberculosis in woman (ab), Nov., 820

YOUNG, BARTON R. See SCANLON, ROBERT L.

YOUNG, W. B. See CAMERON, J. A. P.

ZAIMAN, HERMAN, STONEY, JAMES M., RUBEL, JUNE, and HEADLEY, NORMAN C.: Studies on the nature of immunity to Trichinella spiralis in parabiotic rats. VII. The immune response of the "uninfected" twin one month after its mate received an immunizing dose of irradiated (x ray) larvae (ab), Nov., 833

ZEMAN, WOLFGANG. See MESCHAN, ISADORE

ZIEVE, LESLIE, SKANSE, BENGT, and SCHULTZ, ALVIN L.: Comparative value of the basal metabolic rate, chemical protein-bound iodine, and radioactive iodine excretion or uptake in diagnosis of borderline hyperthyroidism when used individually or in combination (ab), Dec., 962

—See SCHULTZ, ALVIN L.

ZIRCONIUM

—zirconium compounds in contrast radiography: experimental study, Robert Shapiro, Sept., 429

ZIZMOR, JUDAH: Bronchography in the diagnosis of bronchogenic carcinoma in two patients with apparently normal chest films, Dec., 868

ZUPPINGER, A.: Present-day indications for the treatment of tumors of the oral cavity, larynx and pharynx (ab), Aug., 314

ZUSPAN, FREDERICK P.: Development of endometrial carcinoma subsequent to irradiation for carcinoma of the cervix (ab), Nov., 832

ZWANGER, JEROME. See BELL, A. L. L.

ZWICKY, GEORGE. See MAUTHE, HOWARD